



TEXAS INSTRUMENTS

1000

TMS 1000 Family Microcomputers

MICROCOMPUTER SERIES™

Data Book

IMPORTANT NOTICES

Texas Instruments reserves the right to make changes at any time in order to improve design and to supply the best product possible.

TI cannot assume any responsibility for any circuits shown or represent that they are free from patent infringement.

Copyright © 1982
Texas Instruments Incorporated

TABLE OF CONTENTS

1.	THE SINGLE-CHIP MICROCOMPUTERS FROM TEXAS INSTRUMENTS	
1.1	Description	1
1.2	Features	1
1.3	Design Support	1
1.4	TMS 1000 Family Support	4
1.5	Quick-Reference Product Selection	5
1.6	Applications	6
2.	TMS 1000/1200 AND TMS 1070/1270 MICROCOMPUTERS	
2.1	Introduction	7
2.2	ROM Operation	8
2.3	RAM Operation	8
2.4	Arithmetic Logic Unit Operation	8
2.5	Input	9
2.6	Output	9
2.7	Timing Relationships	9
2.8	Software Summary	12
2.9	Sample Program	13
3.	TMS 1700 MICROCOMPUTERS	
3.1	Introduction	16
3.2	ROM Operation	16
3.3	RAM Operation	16
3.4	Output	16
4.	TMS 1100/1300 AND TMS 1170/1370 MICROCOMPUTERS	
4.1	Introduction	17
4.2	ROM Operation	18
4.3	RAM Operation	19
4.4	Output	19
5.	TMS 1400/1600 AND TMS 1470/1670 MICROCOMPUTERS	
5.1	ROM Organization/Chapter Control	20
5.2	RAM Operation	20
5.3	TMS 1400/TMS 1470 Data Input	20
5.4	TMS 1600/TMS 1670 Data Input	20
5.5	K8 Frequency Divider	22
5.6	Data Output	22
5.7	R-Data Output	22
5.8	O-Data Output	22
5.9	Device Software Operation	23
5.9.1	Instruction Set	23
5.9.2	O-Output PLA	23
5.9.3	Subroutine Calls	23
5.10	TMS 1400 Notes	25
6.	TMS 1X70 MICROCOMPUTERS	
6.1	Introduction	26

TABLE OF CONTENTS (Continued)

7.	TMS 1X00 FAMILY POWER-UP AND INITIALIZATION (RESET)	
7.1	Introduction	27
7.2	Power-Up	27
7.2.1	Self-Contained Power-Up Latch	27
7.2.2	INIT Input Pin	27
7.3	Initialization (External Reset)	28
8.	TMS 1000 CMOS MICROPROCESSOR FAMILY	
8.1	Introduction	29
8.2	Timing Relationships and Oscillator Operation	30
8.3	Initialization	30
8.3.1	Power-Up	30
8.3.2	External Reset	30
8.4	Halt	31
8.5	Data Input	31
8.5.1	TMS 1000C Data Input	31
8.5.2	TMS 1200C Data Input	31
8.6	Data Output	33
8.6.1	R-Data Output	33
8.6.2	O-Data Output	33
8.7	Instruction Sets	33
8.7.1	Standard Instruction Set	33
8.8	O-Output PLA	33
8.9	Subroutine Calls	33
8.9.1	Action of Call	33
8.9.2	Action of RETN	34
8.10	Future CMOS Series Products	35
9.	MICROCOMPUTER SYSTEM EVALUATORS	
9.1	SE-1000P, SE-1100P, and SE-1400P	36
9.1.1	Introduction	36
9.1.2	Operation	36
9.1.3	Special SE-1400P Pins Useful for Debugging	39
9.2	SE-1000C and SE-1100C	40
9.2.1	Introduction	40
9.2.2	Operation	40
9.2.3	Special SE-1000C/1100C Pins Useful for Debugging	40
10.	AMPL1000 DEVELOPMENT SYSTEM SUPPORT	
10.1	Introduction	42
10.2	AMPL1000 Components	42
11.	TMS 1000, 1100, 1200, 1300, 1700 (15 VOLT SERIES NLP) ELECTRICAL SPECIFICATIONS	
11.1	TMS 1000, 1100, 1200, 1300, 1700 (15 Volt Series NLP) Absolute Maximum Ratings Over Operating Free-Air Temperature Range	44
11.2	TMS 1000, 1100, 1200, 1300, 1700 (15 Volt Series NLP) Recommended Operating Conditions	44
11.3	TMS 1000, 1100, 1200, 1300, 1700 (15 Volt Series NLP) Electrical Characteristics Over Recommended Operating Free-Air Temperature Range	45
11.4	Internal or External Clock	46
12.	TMS 1070, 1170, 1270, 1370 (15 VOLT SERIES NLP) ELECTRICAL SPECIFICATIONS	
12.1	TMS 1070, 1170, 1270, 1370 (15 Volt Series NLP) Absolute Maximum Ratings Over Operating Free-Air Temperature Range	47

TABLE OF CONTENTS (Continued)

12.2	TMS 1070, 1170, 1270, 1370 (15 Volt Series NLP) Recommended Operating Conditions	47
12.3	TMS 1070, 1170, 1270, 1370 (15 Volt Series NLP) Electrical Characteristics Over Recommended Operating Free-Air Temperature Range	48
12.4	Internal or External Clock	49
13.	TMS 1000, 1100, 1200, 1300, 1400, 1600, 1700 (9 VOLT SERIES NLL) ELECTRICAL SPECIFICATIONS	
13.1	TMS 1000, 1100, 1200, 1300, 1400, 1600, 1700 (9 Volt Series NLL) Absolute Maximum Ratings Over Operating Free-Air Temperature Range	50
13.2	TMS 1000, 1100, 1200, 1300, 1400, 1600, 1700 (9 Volt Series NLL) Recommended Operating Conditions	51
13.3	TMS 1000, 1100, 1200, 1300, 1400, 1600, 1700 (9 Volt Series NLL) Electrical Characteristics Over Recommended Free-Air Temperature Range	52
13.4	Internal or External Clock	54
14.	TMS 1070, 1170, 1270, 1370, 1470, 1670 (9 VOLT SERIES NLL) ELECTRICAL SPECIFICATIONS	
14.1	TMS 1070, 1170, 1270, 1370, 1470, 1670 (9 Volt Series NLL) Absolute Maximum Ratings Over Operating Free-Air Temperature Range	56
14.2	TMS 1070, 1170, 1270, 1370, 1470, 1670 (9 Volt Series NLL) Recommended Operating Conditions	57
14.3	TMS 1070, 1170, 1270, 1370, 1470, 1670 (9 Volt Series NLL) Electrical Characteristics Over Recommended Operating Free-Air Temperature Range	58
14.4	Internal or External Clock	60
15.	TMS 1000C, 1100C, 1200C, 1300C ELECTRICAL SPECIFICATIONS	
15.1	TMS 1000C, 1100C, 1200C, 1300C Absolute Maximum Ratings Over Operating Free-Air Temperature Range	62
15.2	TMS 1000C, 1100C, 1200C, 1300C Recommended Operating Conditions	62
15.3	TMS 1000C, 1100C, 1200C, 1300C Electrical Characteristics Over Recommended Operating Free-Air Temperature Range	63
16.	SE-1000P, 1100P, 1000C, 1100C, 1400P ELECTRICAL SPECIFICATIONS	
16.1	SE-1000P and 1100P Electrical Specifications	68
16.2	SE-1000C Electrical Specifications	69
16.3	SE-1100C Electrical Specifications	70
16.4	SE-1400P Electrical Specifications	71
17.	PIN ASSIGNMENT DIAGRAMS	
17.1	TMS 1000, 1070, 1100, 1200, 1270, 1300, 1370, 1400, 1400A, 1470, 1600, 1670, 1700 Pin Assignment Diagrams	72
17.2	TMS 1000C, 1070C, 1100C, 1200C, 1270C, 1300C, Pin Assignment Diagrams	74
17.3	SE-1000P, 1100P, 1400P, 1000C, 1100C Pin Assignment Diagrams	75
18.	MECHANICAL DATA	

LIST OF ILLUSTRATIONS

FIGURE

1	Design Release Flowchart	3
2	Block Diagram of Typical Application	6
3	TMS 1000/TMS 1200 Logic Blocks	7
4	ALU and Associated Data Paths	8
5	O-Output PLA for Binary and Seven-Segment Encoding	10
6	TMS 1000 Family Output, Input and Instruction Timing	11

LIST OF ILLUSTRATIONS (Continued)

FIGURE

7	Machine Instruction Flowchart BCD Addition Subroutine	15
8	TMS 1700 Logic Blocks	16
9	TMS 1100/1300 Logic Blocks	17
10	TMS 1400 Series Block Diagram	21
11	TMS 1600/TMS 1670 Input Bus Configuration	22
12	Subroutine/Call Flow	23
13	Strobed Fluorescent Display Interconnect	26
14	Power-Up Clear by INIT Input	27
15	Example of Manual Reset Circuit	28
16	Typical Reset Circuit	30
17	TMS 1200C Input Bus Configuration	32
18	Subroutine/Call Flow	34
19	Block Diagram of Typical Application-Prototyping System with SE-1000P or SE-1100P	37
20	Block Diagram of Typical Application-Prototyping System for SE-1400	38
21	Block Diagram of Typical Application-Prototyping System with SE-1000C or SE-1100C	41
22	TMS 1000 CMOS Emulator Machine State Display	43
23	Externally Driven Clock Input Waveform	45
24	TMS 1000, 1100, 1200, 1300, 1700 Schematics of Inputs and Outputs	45
25	TMS 1000 Standard Voltage PMOS Series Typical Oscillator Frequency vs. External Resistance	46
26	TMS 1000 Standard Voltage Series Typical Buffer Characteristics	46
27	Externally Driven Clock Input Waveform	47
28	TMS 1070, 1170, 1270, 1370 Standard Voltage Series of Inputs and Outputs	48
29	TMS 1070 Standard Voltage PMOS Series Typical Oscillator Frequency vs. External Resistance	49
30	Externally Driven Clock Input Waveform	51
31	TMS 1000, 1100, 1200, 1300, 1700 Schematics of Inputs and Outputs	52
32	TMS 1400, 1600 Schematics of Inputs and Outputs	53
33	TMS 1000 Low Voltage Series Typical Oscillator Frequency vs. External Resistance	54
34	TMS 1000 Low Voltage Series Typical Buffer Characteristics	55
35	Externally Driven Clock Input Waveform	57
36	TMS 1070, 1170, 1270, 1370 Low Voltage Series Schematics of Inputs and Outputs	58
37	TMS 1470, 1670 Low Voltage Series Schematics of Inputs and Outputs	59
38	TMS 1000 9 Volt Series Typical Oscillator Frequency vs. External Resistance	60
39	TMS 1070, 1170, 1470, 1670 Typical Buffer Characteristics	61
40	TMS 1000 CMOS Series Schematics of Inputs and Outputs	62
41	Externally Driven Clock Input Waveform	63
42	Internal Oscillator Frequency vs. External Resistance	64
43	I _{DD} vs. Internal Oscillator Frequency	64
44	Normalized Internal Oscillator Frequency vs. V _{DD}	65
45	Maximum Oscillator Frequency vs. V _{DD}	65
46	Input Logic Levels vs. V _{DD}	66
47	Typical Input Current vs. Input Voltage	66
48	Typical Output Source Characteristics	67
49	Typical Output Sink Characteristics	67
50	18-Pin N Plastic Package, 0.100" Pin Center Spacing, 0.300" Pin Row Spacing	77
51	28-Pin NF Plastic package, 0.070" Pin Center Spacing, 0.400" Pin Row Spacing	78
52	28-Pin N Plastic Package, 0.100" Pin Center Spacing, 0.600" Pin Row Spacing	78
53	40-Pin NF Plastic Package, 0.070" Pin Center Spacing, 0.600" Pin Row Spacing	79
54	40-Pin N Plastic Package, 0.100" Pin Center Spacing, 0.600" Pin Row Spacing	79
55	64-Pin J Ceramic Package, 0.100" Pin Center Spacing, 0.900" Pin Row Spacing	80

LIST OF TABLES

TABLE

1	TMS 1000 Family Summary	4
2	Quick-Reference Selection Guide	5
3	TMS 1000/TMS 1200 and TMS 1700 Standard Instruction Set	12
4	TMS 1100/1300 Standard Instruction Set	18
5	K/L Selector and SE Mode Selector Functions	22
6	TMS 1000 CMOS Series Features	29
7	K/L Selector and SE Mode Selector Functions	32
8	System Evaluators	36
9	K8 Divider Options	39
10	TMS 1000 Device Types vs. AMPL1000 Emulators	43
11	Pin Description	72
12	Pin Description	74
13	SE-1000P and SE-1100P Terminal Function Description	75

1. THE SINGLE-CHIP MICROCOMPUTERS FROM TEXAS INSTRUMENTS

1.1 DESCRIPTION

The TMS 1000 family of microcomputers from Texas Instruments offers a low cost, high reliability, single chip solution for many applications. Low development costs and the accumulation of product experience favor the microcomputer approach. Currently there are over 600 TMS 1000 Programmers or 60 million units installed in the field making the TMS 1000 the most pervasive microcomputer in the world.

The TMS 1000 series is a family of MOS/LSI four-bit microcomputers with a ROM, a RAM, and an arithmetic logic unit on a single semiconductor chip. A customer's specification determines the software that is reproduced during wafer processing by a single-level mask technique that defines a fixed ROM pattern. As summarized in 1.4, the TMS 1000 and TMS 1200 are the basic 1024-instruction ROM microcomputers. The TMS 1070 and TMS 1270 interface directly to high-voltage displays and use instructions identical to the TMS 1000/1200 devices. To increase the software capacity in one chip, the TMS 1100/TMS 1300 and TMS 1170/TMS 1370 provide twice the ROM and RAM size of the TMS 1000/TMS 1200 while the TMS 1400/1600, TMS 1470/1670 microcomputers have a 4096 eight-bit instruction ROM.

1.2 FEATURES

- 4-bit architecture
- 0.5K X 8 to 4K X 8 program ROM
- 32 X 4 to 128 X 4 scratchpad RAM
- 6 to 16 independent R-output lines
- 5 to 8 decoded O-output lines
- 4 unlatched inputs
- 4 latched inputs (TMS 1600/1670, TMS 1200C/1300C)
- Onboard input frequency divider (TMS 1400 series)
- 9 or 15 V PMOS operation or 5 V CMOS
- VF display interfacing (TMS 1X70)
- PMOS power consumption from 36 mW
- CMOS power consumption from 0.5 μ W

1.3 DESIGN SUPPORT

TI provides support for the entire TMS 1000 series:

- System evaluators with an external EPROM.
- Complete stand-alone development system for program development.
- Microcomputer application specialists nationwide for local design assistance.
- Regional Technology Centers.

A staff of experienced application programmers is available at Texas Instruments to assist customers in evaluating applications, in training designers to program the TMS 1000 series, and in simulating programs. TI will also contract to write programs to customer's specifications.

Figure 1 is a flow diagram for software development through prototyping and production release.

A TMS 1000 series program (see flowchart, Figure 1) is written in assembly language using standard mnemonics. The assembler converts the source code (assembly language program) into machine code, which is transferred to an AMPL emulator. Also, the assembler produces a machine code object file. The object file is used for hardware simulation or for generating prototype tooling.

The TMS 1000 series programs are checked by system evaluators and hardware simulation. The hardware simulation offers the designer the advantages of real-time simulation and testing asynchronous inputs. System evaluators are suited for field testing and limited production volumes.

After the algorithms have been checked and approved by the customer, the final object code and machine options statements are supplied to TI. A gate mask is generated and slices produced. After assembly and testing, the prototypes are shipped to the customer for approval. Upon receiving final approval, the part is released for volume production at the required rate as one unique version of the TMS 1000 family.

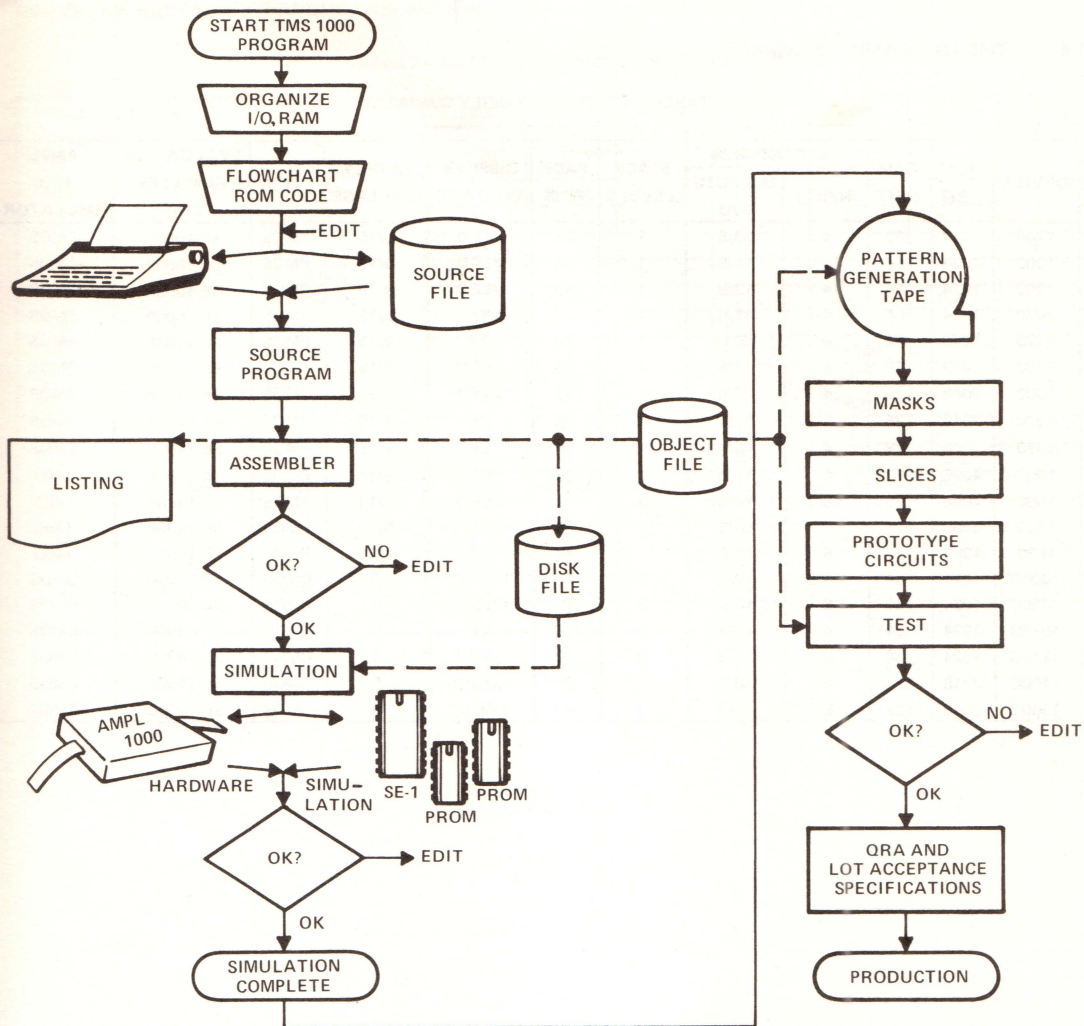


FIGURE 1 – DESIGN RELEASE FLOWCHART

1.4 TMS 1000 FAMILY SUMMARY

TABLE 1 – TMS 1000 FAMILY SUMMARY

DEVICE	ROM 8 BIT	RAM 4 BIT	I/O FEATURES		STACK LEVELS	PACK PINS	DISPLAY VOLTAGE	SUPPLY VOLTAGE	TECH.	EVALUATION ROM-LESS CHIP	AMPL 1000 EMULATOR
			INPUTS	OUTPUTS R/O							
1700	512	32	4	9/8	1	28	VLED	9/15	PMOS	SE-1000P	PMOS
1000	1024	64	4	11/8	1	28	VLED	9/15	PMOS	SE-1000P	PMOS
1200	1024	64	4	13/8	1	40	VLED	9/15	PMOS	SE-1000P	PMOS
1070	1024	64	4	11/8	1	28	VF	9/15	PMOS	SE-1000P	PMOS
1270	1024	64	4	13/10	1	40	VF	9/15	PMOS	SE-1000P	PMOS
1100	2048	128	4	11/8	1	28	VLED	9/15	PMOS	SE-1100P	PMOS
1300	2048	128	4	16/8	1	40	VLED	9/15	PMOS	SE-1100P	PMOS
1170	2048	128	4	11/8	1	28	VF	9/15	PMOS	SE-1100P	PMOS
1370	2048	128	4	16/8	1	40	VF	9/15	PMOS	SE-1100P	PMOS
1400	4096	128	4	11/8	3	28	VLED	9/15	PMOS	SE-1400P	1400
1600	4096	128	8	16/8	3	40	VLED	9/15	PMOS	SE-1400P	1400
1470	4096	128	4	10/8	3	28	VF	9/15	PMOS	SE-1400P	1400
1670	4096	128	8	16/8	3	40	VF	9/15	PMOS	SE-1400P	1400
1000C	1024	64	4	10/8	3	28	LOGIC	5	CMOS	SE-1000C	CMOS
1200C	1024	64	8	16/8	3	40	LOGIC	5	CMOS	SE-1000C	CMOS
1070C	1024	64	4	10/8	3	28	VF	5	CMOS	SE-1000C	CMOS
1270C	1024	64	8	16/8	3	40	VF	5	CMOS	SE-1000C	CMOS
1100C	2048	128	4	10/8	3	28	LOGIC	5	CMOS	SE-1100C	CMOS
1300C	2048	128	8	16/8	3	40	LOGIC	5	CMOS	SE-1100C	CMOS

1.5 QUICK-REFERENCE PRODUCT SELECTION

TABLE 2 – QUICK-REFERENCE SELECTION GUIDE

PART NUMBER			10XX	11XX	12XX	13XX	14XX	16XX	17XX
ROM		512 X 8 bits							P, L
		1024 X 8 bits	P, L, C		P, L, C				
		2048 X 8 bits		P, L, C		P, L, C			
		4046 X 8 bits					P, L	P, L	
RAM		32 X 4 bits							P, L
		64 X 4 bits	P, L, C		P, L, C				
		128 X 4 bits		P, L, C		P, L, C	P, L	P, L	
OUTPUTS	R lines	9 lines							P, L
		10 lines	C	C			1470P		
		11 lines	P, L	P, L			1400P/ 1400L		
		13 lines			P, L				
	O lines	16 lines			C	P, L, C		P, L	
		8 lines	P, L, C	P, L, C	P, L, C	P, L, C	P, L	P, L	P, L
		10 lines			1270P				
INPUTS	K lines	non-latching	P, L, C	P, L, C	P, L, C	P, L, C	P, L	P, L	P, L
	L lines	latching			C	C		P, L	
SUBROUTINES		1 level, same page	P, L	P, L	P, L	P, L			P, L
		3 levels, any page	C	C	C	C	P, L	P, L	

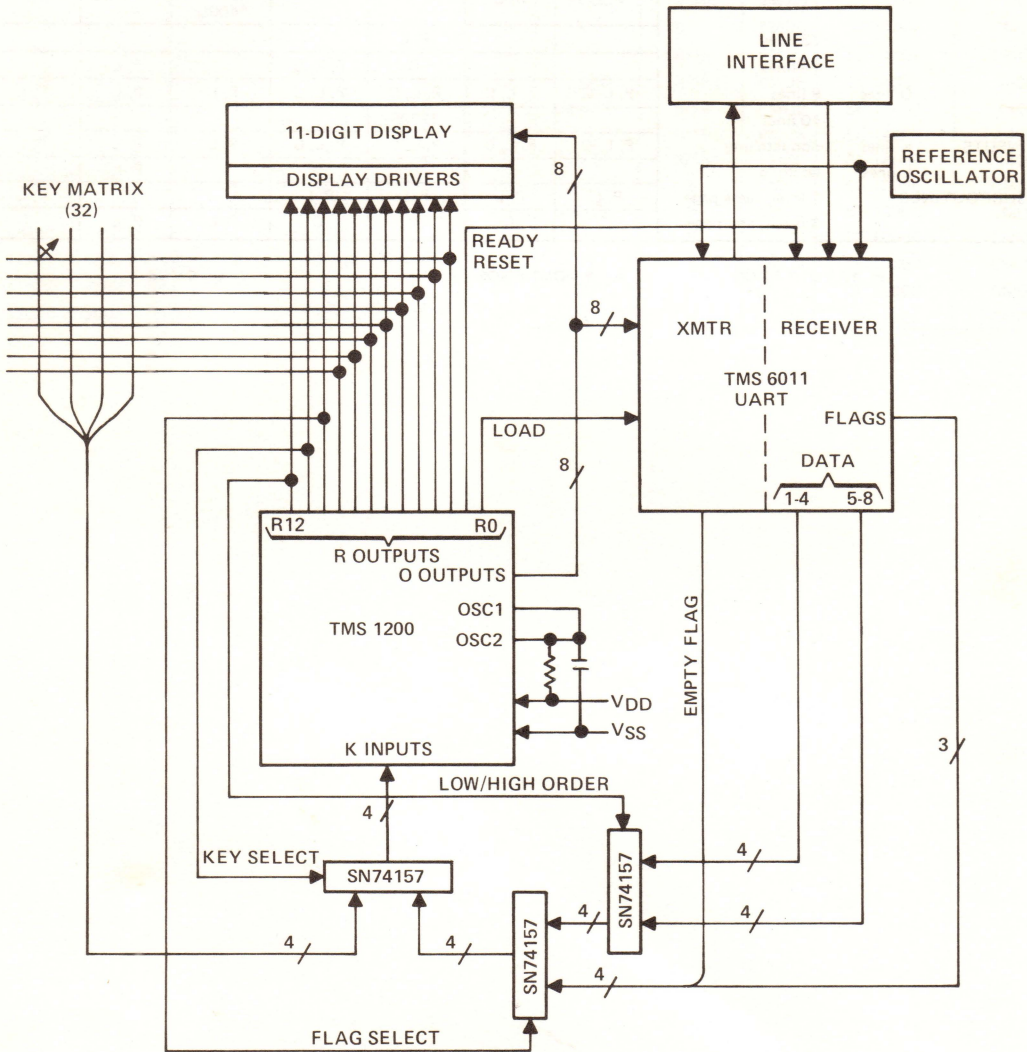
P: 15 VOLT PMOS

L: 9 VOLT PMOS

C: CMOS

1.6 APPLICATIONS

One major advantage of the TMS 1000 series is flexibility. The TMS 1000 series is effective in applications such as printer controllers, data terminals, remote sensing systems, cash registers, appliance controls, and automotive applications. A data terminal is a useful example. In Figure 2, a sample interconnect diagram shows how the R outputs control a universal asynchronous receiver/transmitter (UART), display scan, and keyboard scan. The ROM controls data output to the appropriate display digit or to the transmitter section of the UART. A routine in the ROM program controls selection of incoming data through the K-input ports. Two dedicated R outputs (load and ready reset) control the UART's transmit and receive modes. The remaining R outputs both scan the display and select inputs. The SN74157 TTL devices multiplex eight bits of the incoming data word, four bits of UART status, and the four key input lines. Through the TMS 1000 series' versatility, a wide range of systems realize reduced costs, fewer parts, and high reliability.



NOTE: Discrete components for level shifting and other functions are not shown.

FIGURE 2 – BLOCK DIAGRAM OF TYPICAL APPLICATION—TERMINAL CONTROLLER

2. TMS 1000/1200 AND TMS 1070/1270 MICROCOMPUTERS

2.1 INTRODUCTION

The TMS 1000/1200 and TMS 1070/1270 are identical except for maximum voltage ratings for the K inputs and the O and R outputs, and the TMS 1270 has a total of ten O outputs.

The microcomputer's ROM program controls data input, storage, processing, and output. Data processing takes place in the arithmetic logic unit. K input data goes into the ALU, as shown in Figure 3, and is stored in the four-bit accumulator. The accumulator output accesses the output latches, the RAM storage cells, and the adder input. Data storage in the 256-bit RAM is organized into 64 words, four bits per word. The four-bit words are conveniently grouped into four 16-word files addressed by a two-bit register. A four-bit register addresses one of the 16 words in a file by ROM control.

The O outputs and the R outputs are the output channels. The eight parallel O outputs are decoded from five data latches. The O outputs serve many applications because the decoder is a programmable logic array (PLA) that is modified by changing the gate-level mask tooling. Each of the thirteen R outputs of the TMS 1200 and the eleven R outputs on the TMS 1000 has an individual storage element that can be set or reset by program control. The R outputs send status or enable signals to external devices. The R outputs strobe the O outputs to displays, to other TMS 1000 series chips, or to TTL and other interface circuits. The same R outputs multiplex data into the K inputs whenever necessary.

There are 43 basic instructions that handle I/O, constant data from the ROM, bit control, internal data transfer, arithmetic processing, branching, looping, and subroutines. The eight-bit instruction word performs 256 unique operations for maximum efficiency. Section 2.8 defines the standard instruction set, which is optimized for most programs.

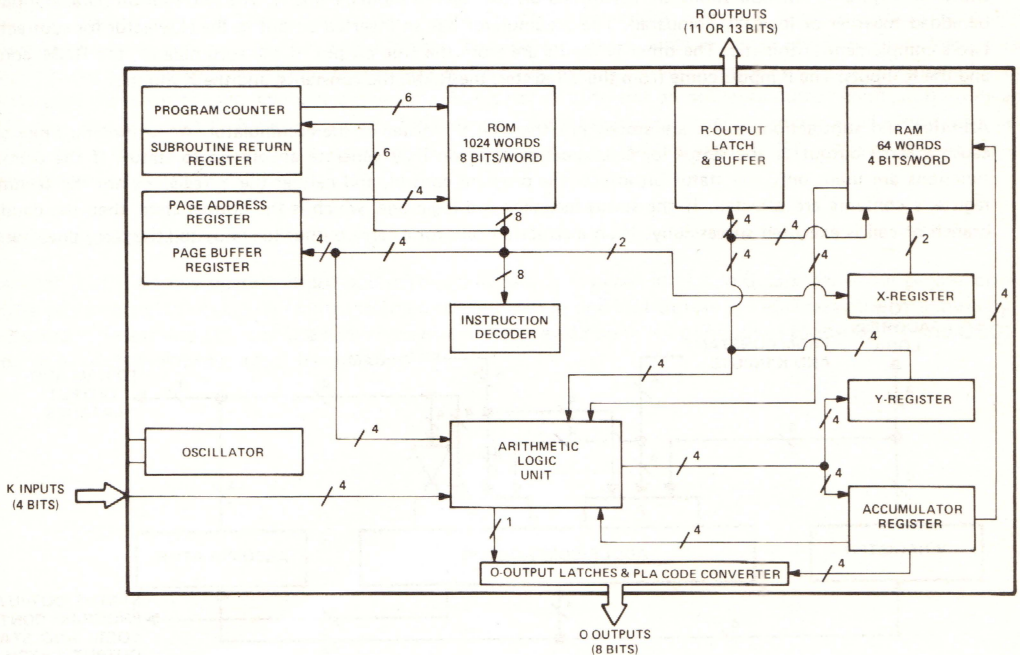


FIGURE 3 — TMS 1000/TMS 1200 LOGIC BLOCKS

2.2 ROM OPERATION

The sequence of the 1024 eight-bit ROM instructions determines the device operation. There are 16 pages of instructions with 64 instructions on each page. After power-up the program execution starts at a fixed instruction address. Then a shift-register program counter sequentially addresses each ROM instruction on a page. A conditional branch or call subroutine instruction may alter the six-bit program-counter address to transfer software control. One level of subroutine return address is stored in the subroutine return register. The page address register (four bits) holds the current address for one of the 16 ROM pages. To change pages, a constant from the ROM loads into the page buffer register (four bits), and upon a successful branch or call, the page buffer loads into the page address register. The page buffer register also holds the return page address in the call subroutine mode.

2.3 RAM OPERATION

There are 256 addressable bits of RAM storage available. The RAM is comprised of four files, each file containing 16 four-bit words. The RAM is addressed by the Y register and the X register. The Y register selects one of the 16 words in a file and is completely controllable by the arithmetic unit. The TMS 1000 series has instructions that: Compare Y to a constant, set Y to a constant, increment or decrement Y, and/or perform data transfer to or from Y. Two bits in the X register select one of the four 16-word files. The X register is set to a constant or is complemented. A four-bit data word goes to the RAM location addressed by X and Y from the accumulator or from the constants in the ROM. The RAM output words go to the arithmetic unit and can be operated on and loaded into Y or the accumulator in one instruction interval. Any selected bit in the RAM can be set, reset, or tested.

2.4 ARITHMETIC LOGIC UNIT OPERATION

Arithmetic and logic operations are performed by the four-bit adder and associated logic. The arithmetic unit performs logical comparison, arithmetic comparison, add, and subtract functions. The arithmetic unit and interconnects are shown in Figure 4. The operations are performed on two sets of inputs, P and N. The two four-bit parallel inputs may be added together or logically compared. The accumulator has an inverted output to the N selector for subtraction by two's complement arithmetic. The other N inputs are from the true output of the accumulator, the RAM, constants, and the K inputs. The P inputs come from the Y register, the RAM, the constants, and the K inputs.

Addition and subtraction results are stored in either the Y register or the accumulator. An arithmetic function may cause a carry output to the status logic. Logical comparison may generate an output to status. If the comparison functions are used, only the status bit affects the program control, and neither the Y register's nor the accumulator register's contents are affected. If the status feedback is a logic one, which is the normal state, then the conditional branch or call is executed successfully. If an instruction calls for a carry output to status and the carry does not occur,

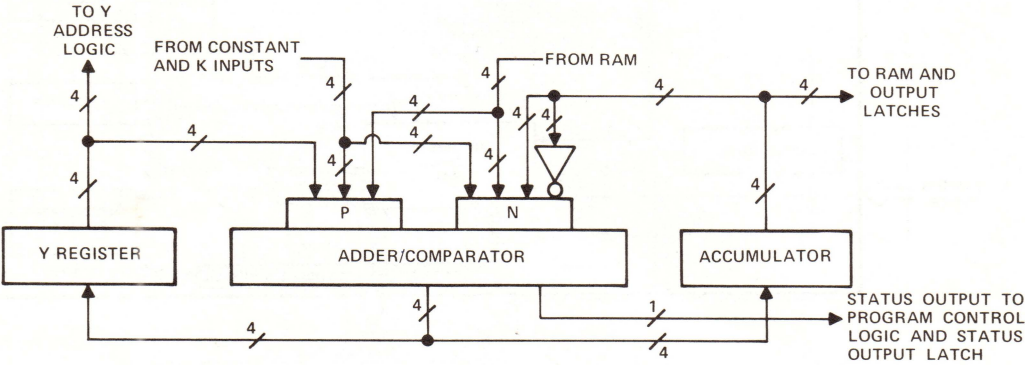


FIGURE 4 – ALU AND ASSOCIATED DATA PATHS

then status will go to a zero state for one instruction cycle. Likewise, if an instruction calls for the logical-comparison function and the bits compared are all equal, then status will go to a zero state for one instruction cycle. If status is a logic zero, then branches and calls are not performed successfully.

2.5 INPUT

There are four data inputs to the TMS 1000-series circuit, K1, K2, K4, and K8. Each time an input word is requested, the data path from the K inputs is enabled to the adder. The inputs are either tested for a high level ($\approx V_{SS}$), or the input data are stored in the accumulator for further use. The R outputs usually multiplex inputs such as keys and other data. Other input interfaces are possible. An external device that sends data out to the K-input bus at a fixed rate may be used with the TMS 1000 series when an initiating "handshake" signal is given from an R output. Data from the K inputs is stored periodically in synchronization with the predetermined data rate of the external device. Thus, multiple four-bit words can be requested and stored with only one R output supplying the control signal.

2.6 OUTPUT

There are two output channels with multiple purposes, the R outputs and the O outputs. Thirteen latches store the R output data. The eight parallel O outputs come from a five-bit-to-eight-bit code converter, which is the O-output PLA. The R outputs are individually addressed by the Y register. Each addressed bit can be set or reset.

The R outputs are normally used to multiplex inputs and strobe O output data to displays, external memories, and other devices. Also, one R output can strobe other R outputs that represent variable data, because every R output may be set or reset individually. For example, the Y register addresses each latch in turn; the variable data R outputs are set or reset; and finally, the data strobe R latch is set.

The eight O outputs usually send out display or binary data that are encoded from the O output latches. The O latches contain five bits. Four bits load from the accumulator in parallel. The fifth bit comes from the status latch, which is selectively loaded from the adder output (see Figure 4). The load output command sends the status latch and accumulator information into the five output latches. The five bits are available in true or complementary form to 20 programmable-input NAND gates in the O output PLA. Each NAND gate can simultaneously select any combination of O0 through O7 as an output. The user defines this PLA's decoding to suit an optimum output configuration. As an illustration, the O output PLA can encode any 16 characters of eight-segment display information and additionally can transfer out a four-bit word of binary data. Figure 5 shows a display interface example (SL = 1) and also illustrates binary data transmission (SL = 0).

2.7 TIMING RELATIONSHIPS

The TMS 1000 Family output, input and instruction timing is given in Figure 6. Six oscillator pulses constitute one instruction cycle. All instructions are executed in one instruction cycle. The actual machine cycle period is determined by either a fixed external resistor and capacitor connected to the OSC1 and OSC2 pins, or an external clock input frequency.

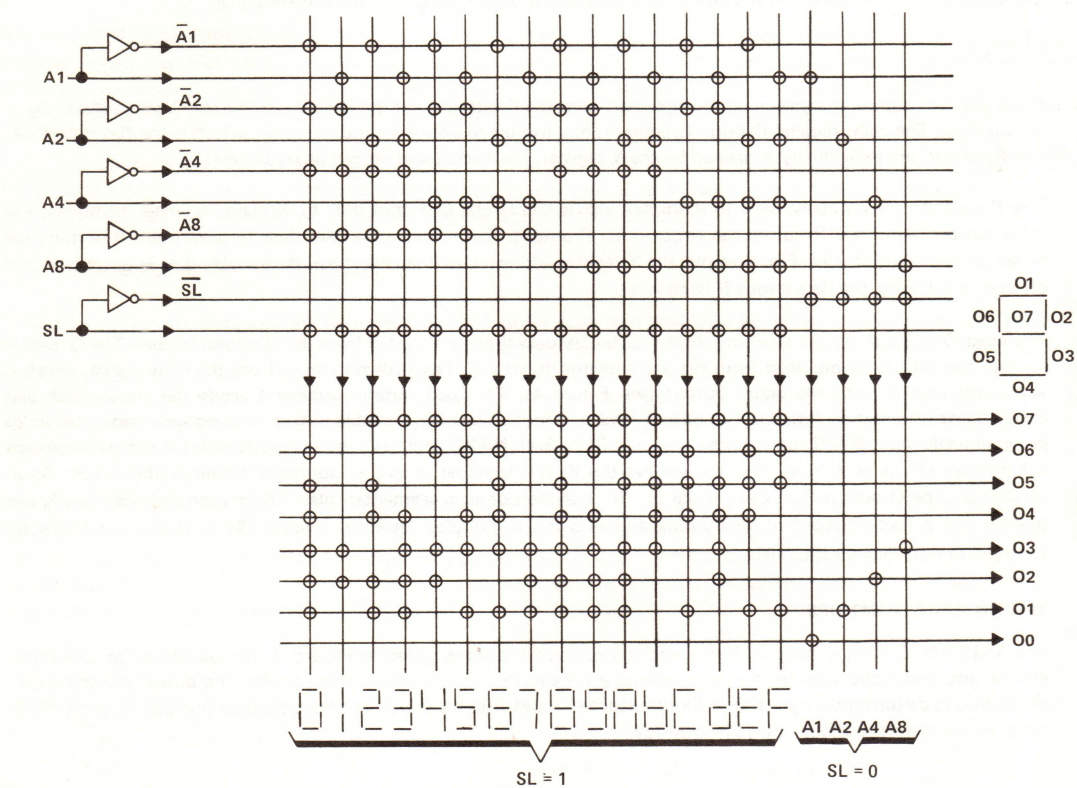
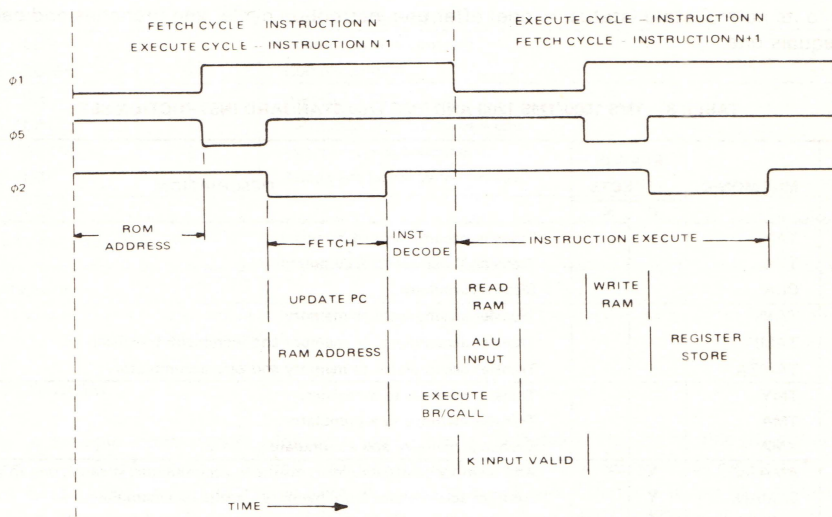
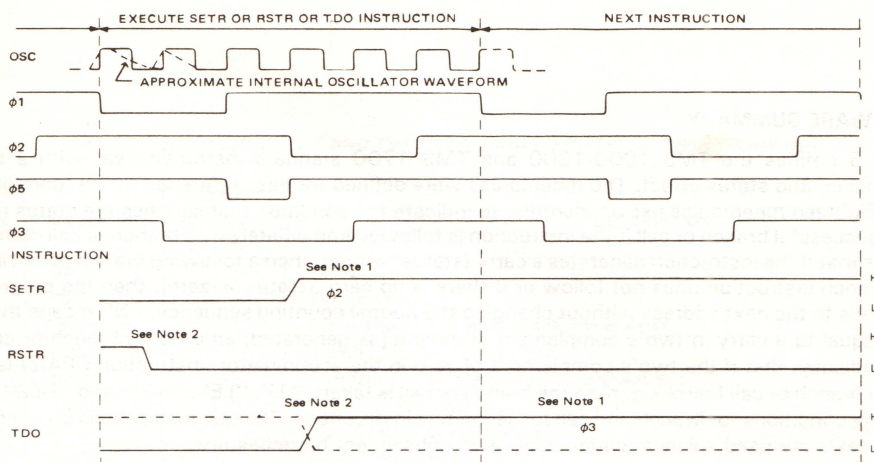


FIGURE 5 — O OUTPUT PLA FOR BINARY AND SEVEN-SEGMENT ENCODING



NOTES: 1. Initial rise time is load dependent. The high level output voltage, V_{OH} , is characterized following the indicated clock period.
2. Rise and fall times are load dependent.

FIGURE 6 – TMS 1000 FAMILY OUTPUT, INPUT AND INSTRUCTION TIMING

2.8 SOFTWARE SUMMARY

Table 3 defines the TMS 1000/1200 and TMS 1700 standard instruction set with a description, mnemonic, and status effect. The mnemonics were defined for easy reference to the functional description. Eighteen mnemonics use an identifier to indicate the condition that satisfies the status requirement for a successful branch or call if the instruction is followed immediately by a branch or call command. "C" means that if the instruction generates a carry (status = one), then a following branch or call is executed. If a branch instruction does not follow or if there is no carry (status = zero), then the program counter proceeds to the next address without changing the normal counting sequence. "N" means that if no borrow (equal to a carry in two's complement arithmetic) is generated, an ensuing branch or call is taken. "Z" indicates that if the two's complement of zero in the accumulator (instruction CPAIZ) is attempted with a branch or call following, then the branch or call is taken. "1", "LE", "NE", and "NEZ" are used to indicate conditions for branch and call for seven test instructions. The test instructions do not modify data at all; tests are used solely in conjunction with subsequent branches or calls.

If an instruction that does not affect status is placed between an instruction that does affect status and a branch or call instruction, then the branch or call is always successful. This is true because status always returns to its normal state (status = one) after one instruction cycle, and branches and calls are taken if status equals one.

TABLE 3 – TMS 1000/TMS 1200 AND TMS 1700 STANDARD INSTRUCTION SET

FUNCTION	MNEMONIC	STATUS EFFECTS		DESCRIPTION
		C	N	
Register to Register	TAY			Transfer accumulator to Y register.
	TYA			Transfer Y register to accumulator.
	CLA			Clear accumulator.
Transfer Register to Memory	TAM			Transfer accumulator to memory.
	TAMIY			Transfer accumulator to memory and increment Y register.
	TAMZA			Transfer accumulator to memory and zero accumulator.
Memory to Register	TMY			Transfer memory to Y register.
	TMA			Transfer memory to accumulator.
	XMA			Exchange memory and accumulator.
Arithmetic	AMAAC	Y		Add memory to accumulator, results to accumulator. If carry, one to status.
	SAMAN	Y		Subtract accumulator from memory, results to accumulator. If no borrow, one to status.
	IMAC	Y		Increment memory and load into accumulator. If carry, one to status.
	DMAN	Y		Decrement memory and load into accumulator. If no borrow, one to status.
	IA			Increment accumulator, no status effect.
	IYC	Y		Increment Y register. If carry, one to status.
	DAN	Y		Decrement accumulator. If no borrow, one to status.
	DYN	Y		Decrement Y register. If no borrow, one to status.
	A6AAC	Y		Add 6 to accumulator, results to accumulator. If carry, one to status.
	A8AAC	Y		Add 8 to accumulator, results to accumulator. If carry, one to status.
	A10AAC	Y		Add 10 to accumulator, results to accumulator. If carry, one to status.
	CPAIZ	Y		Complement accumulator and increment. If then zero, one to status.
Arithmetic Compare	ALEM	Y		If accumulator less than or equal to memory, one to status.
	ALEC	Y		If accumulator less than or equal to a constant, one to status.
Logical Compare	MNEZ		Y	If memory not equal to zero, one to status.
Compare	YNEA		Y	If Y register not equal to accumulator, one to status and status latch.
	YNEC		Y	If Y register not equal to a constant, one to status.

— CONTINUED —

TABLE 3 – TMS 1000/TMS 1200 AND TMS 1700 STANDARD INSTRUCTION SET (Continued)

FUNCTION	MNEMONIC	STATUS EFFECTS		DESCRIPTION
		C	N	
Bits in Memory	SBIT			Set memory bit.
	RBIT			Reset memory bit.
	TBIT1		Y	Test memory bit. If equal to one, one to status.
Constants	TCY			Transfer constant to Y register.
	TCMIY			Transfer constant to memory and increment Y.
Input	KNEZ		Y	If K inputs not equal to zero, one to status.
	TKA			Transfer K inputs to accumulator.
Output	SETR			Set R output addressed by Y.
	RSTR			Reset R output addressed by Y.
	TDO			Transfer data from accumulator and status latch to O outputs.
	CLO			Clear O-output register.
RAM 'X' Addressing	LDX			Load 'X' with a constant.
	COMX			Complement 'X'.
ROM Addressing	BR			Branch on status = one.
	CALL			Call subroutine on status = one.
	RETN			Return from subroutine.
	LDP			Load page buffer with constant.

NOTES: C-Y (Yes) means that if there is a carry out of the MSB, status output goes to the one state. If no carry is generated, status output goes to the zero state.

N-Y (Yes) means that if the bits compared are not equal, status output goes to the one state. If the bits are equal, status output goes to the zero state.

A zero in status remains through the next instruction cycle only. If the next instruction is a branch or call and status is a zero, then the branch or call is not executed successfully.

29 SAMPLE PROGRAM

The following example shows register addition of up to fifteen BCD digits. The add routine (flow charted in Figure 7) can use the entire RAM, which is divided into two pairs of registers. The definition of registers, for the purpose of illustration, is expanded to include the concept of a variable-length word that is a subset of a 16-digit file. Addition proceeds from the least-significant digit (LSD) to the most-significant digit (MSD), and carry ripples through the accumulator. The decrement-Y instruction is used to index the numbers in a register. The initial Y value sets the address for the LSD's of two numbers to be added. Thus, if Y equals eight at the start, the LSD is defined to be stored in M(X,8), [M(X,Y) ≡ contents of RAM word location X equals 0, 1, 2, or 3, and Y equals 0 to 15]. If Y is eight initially, M(X,7) is the next-most-significant digit.

RAM DATA MAP BEFORE EXECUTING SAMPLE ROUTINE

FILE ADDRESS	REGISTER	Y-REGISTER ADDRESS															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
X = 00	D	OV	MSD														
		0	9	8	7	6	5	4	3	LSD							
X = 01	E	OV	MSD														
		0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	LSD
X = 10	F	OV	MSD														
		0	5	4	3	2	1	0	9	8	7	6	5	4	3	2	LSD
X = 11	G	OV	MSD														
		0	8	7	6	5	4	3	2	LSD							

OV ≡ overflow, MSD ≡ most-significant digit, and LSD ≡ least-significant digit

In the preceding RAM register assignment map, registers D and G are nine digits long, and registers E and F are 16 digits long. The sample routine calls the D plus G \rightarrow D subroutine and the E plus F \rightarrow E subroutine. After executing the two subroutines, the RAM contents are the following:

		RAM DATA MAP AFTER EXECUTING SAMPLE ROUTINE															
FILE ADDRESS	REGISTER	Y-REGISTER ADDRESS															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
X = 00	D	OV	MSD														
		1	8	6	4	1	9	7	5	LSD							
X = 01	E	OV	MSD														LSD
		0	6	6	6	6	6	7	7	7	6	6	6	6	6	6	6
X = 10	F	OV	MSD														LSD
		0	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1
X = 11	G	OV	MSD														
		0	8	7	6	5	4	3	2	1							

NOTE: Shaded areas indicate locations in the RAM that are unaffected by executing the example routine.

		LABEL	OPCODE	OPERAND	COMMENT
MAIN PROGRAM PRESETS Y, AND CALL SUBROUTINES	{		TCY	8	Transfer 8 \rightarrow Y
			CALL	ADGD	Add: D + G \rightarrow D
			TCY	15	Transfer 15 \rightarrow Y
			CALL	AEFE	Add: E + F \rightarrow E
MULTIPLE ENTRY POINTS FOR SUBROUTINES	{		ADGG	LDX	3 \rightarrow X; Set up for D + G \rightarrow G.
			BR	BCDADD	Branch to BCD add.
			AEFF	LDX	2 \rightarrow X; Set up for E + F \rightarrow F.
			BR	BCDADD	Branch to BCD add.
			AEFE	LDX	1 \rightarrow X; Set up for E + F \rightarrow E.
			BR	BCDADD	Branch to BCD add.
			ADGD	LDX	0 \rightarrow X; Add D + G \rightarrow D.
			BCDADD	CLA	Clear accumulator (A).
			LOOP	COMX	$\bar{X} \rightarrow X$.
				AMAAAC	M(X,Y) + A \rightarrow A; A contains possible carry if in loop.
BASE SUBROUTINE CONTAINS LOOPING AND BCD CORRECTION	{			COMX	$\bar{X} \rightarrow X$.
				AMAAAC	Add digits: M(X,Y) + [M(\bar{X} ,Y) + Carry] \rightarrow A.
			BR	GT9	Branch if sum > 15.
			ALEC	9	If A \leq 9, one to status.
			BR	LT10	Branch if sum < 10.
			GT9	A6AAC	Sum > 9, A + 6 \rightarrow A;
					BCD Correction.
				TAMZA	Transfer corrected sum to memory, 0 \rightarrow A.
			IA		1 \rightarrow A; to propagate carry
			DYN		Y - 1 \rightarrow Y; index next digit.
	{		BR	LOOP	If no borrow, continue.
			RETN		If borrow, return to instruction after call.
			LT10	TAMZA	Sum < 9, A \rightarrow M(X,Y); 0 \rightarrow A;
					No carry propagated.
			BR	DECY	

3. TMS 1700 MICROCOMPUTERS

3.1 INTRODUCTION

The TMS 1700 is identical to the TMS 1000 except that the TMS 1700 has half as much ROM and RAM as the TMS 1000, and has nine R-outputs, as opposed to eleven R-outputs on the TMS 1000 (See Figure 8).

3.2 ROM OPERATION

The TMS 1700 ROM is organized into eight pages, each page containing 64 instruction words. The instruction word in ROM is comprised of eight bits. Each page is addressed by a three-bit Page Address Register. The Page Buffer Register, which is loaded with a constant from ROM in order to change pages upon a successful branch or call, is also three bits wide. With these exceptions, the TMS 1700 ROM is identical to ROM operations of the TMS 1000.

3.3 RAM OPERATION

There are 128 bits of RAM on the TMS 1700. The RAM is comprised of four files, each file containing eight four-bit words. The RAM is addressed by the X-register and the Y-register. The two-bit X-register selects one of the four 8-word files. The three least significant bits of the 4-bit Y-register select one of the eight words in the file. The most significant bit of the Y-register is not used for RAM addressing.

3.4 OUTPUT

The TMS 1700 has two output channels, the R-outputs and the O-outputs. Nine latches store the R-output data and are addressed by the four bits of the Y-register. The eight parallel O-outputs come from a five-bit-to-eight-bit code converter, which is the O-output PLA identical to the PLA on the TMS 1000.

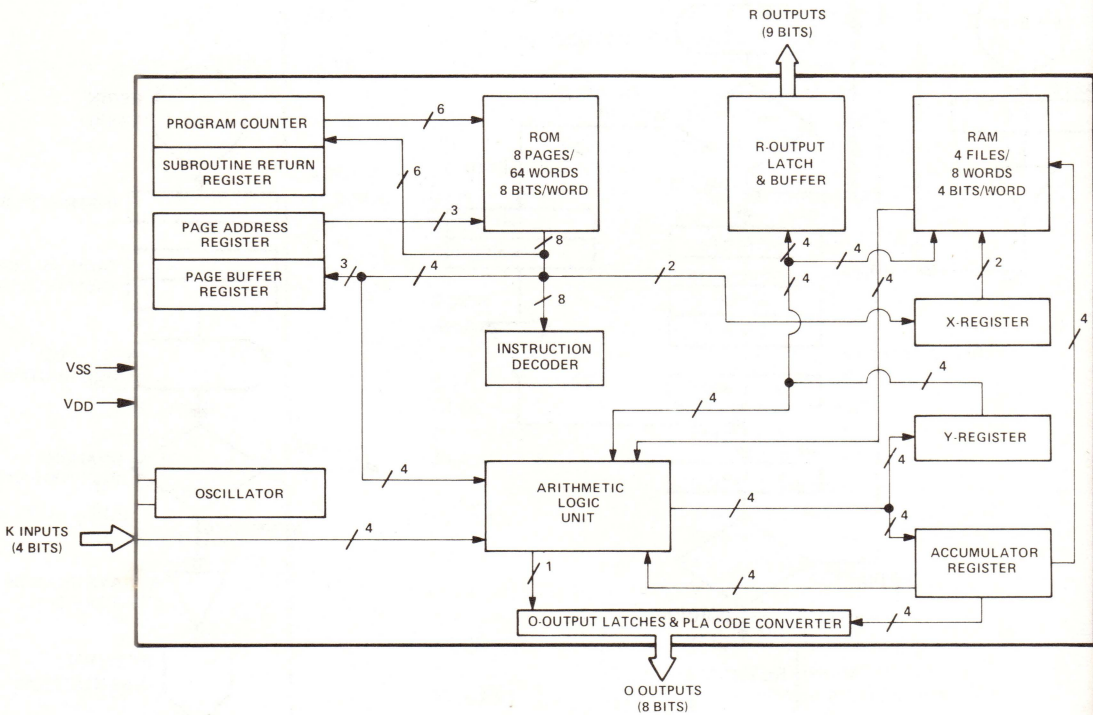


FIGURE 8 - TMS 1700 LOGIC BLOCKS

4. TMS 1100/1300 AND TMS 1170/1370 MICROCOMPUTERS

4.1 INTRODUCTION

Texas Instruments increased the four-bit microprocessor capability with an expanded one-chip microcomputer containing all of the TMS 1000 features plus twice the ROM and RAM capacity (see Figure 9). Two versions of the expanded memory device are available.

TMS 1100/1170

- Pin-for-pin interchangeable with the TMS 1000
- 16,384-bit ROM, 2048 eight-bit instruction words
- 512-bit RAM, 128 four-bit data words
- 11 individually latched R outputs, 28-pin package

TMS 1300/1370

- 16,384-bit ROM
- 512-bit RAM
- 16 individually latched R outputs, 40-pin package

Many industrial, consumer, and business applications can be implemented with a microcomputer having the capabilities of two TMS 1000 devices. With considerably lower system cost, the TMS 1100/1300 single-device microcomputers enable a number of applications that previously required two TMS 1000's or external read/write memory. In the 40-pin version, the TMS 1300, the maximum number of R outputs is increased to 16. Displays 16 characters long as well as a 64-position keyboard or switch matrix (16 X 4) are scanned directly by the TMS 1300.

The TMS 1100/1300 operation is identical to that of the TMS 1000/1200 except where noted otherwise in the following paragraphs. Since the TMS 1100/1300 has identical hardware to the TMS 1000/1200 but contains twice the RAM and ROM capacity, considerable software flexibility is available to the designer.

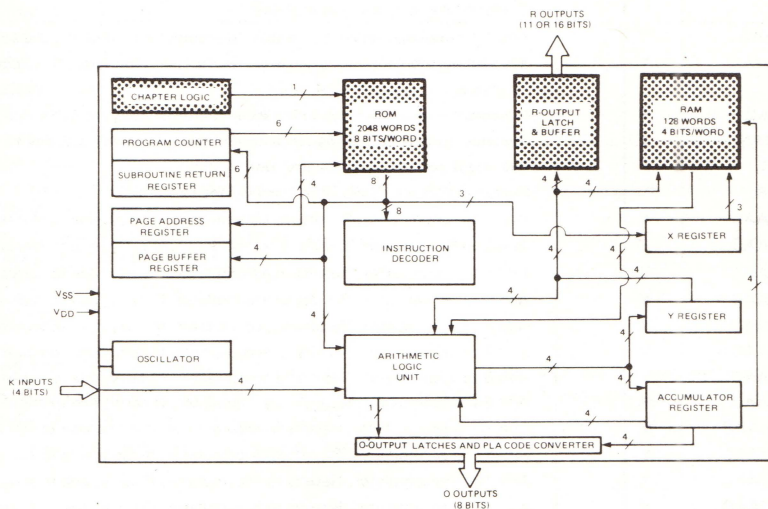


FIGURE 9 – TMS 1100/1300 LOGIC BLOCKS

4.2 ROM OPERATION

The TMS 1100/1300 instruction ROM contains two chapters of 16 pages each. A page contains 64 eight-bit words. The chapter logic consists of three control bits, chapter address, chapter buffer, and chapter subroutine. The chapter buffer bit is controlled by a complement chapter buffer instruction (see COMC in Table 4). The chapter buffer bit transfers into the current chapter address if a branch or call executes successfully. If a call is successful, the return chapter is saved in a chapter subroutine latch. Since the buffer bit is changeable without affecting the chapter subroutine-return address, up to 128 words that are contained on two pages of alternate chapters are available in a single subroutine. The program counter and page addressing operation is identical to the TMS 1000/1200 explained in 2-2.

TABLE 4
TMS 1100/1300 STANDARD INSTRUCTION SET

FUNCTION	MNEMONIC	STATUS EFFECT		DESCRIPTION
		C	N	
Register-to-Register Transfer	TAY			Transfer accumulator to Y register
	TYA			Transfer Y register to accumulator
	CLA			Clear accumulator
Register to Memory	TAM			Transfer accumulator to memory
	TAMIYC	Y		Transfer accumulator to memory and increment Y register. If carry, one to status.
	TAMDYN	Y		Transfer accumulator to memory and decrement Y register. If no borrow, one to status.
Memory to Register	TAMZA			Transfer accumulator to memory and zero accumulator
	TMY			Transfer memory to Y register
	TMA			Transfer memory to accumulator
Arithmetic	XMA			Exchange memory and accumulator
	AMAAC	Y		Add memory to accumulator, results to accumulator. If carry, one to status.
	SAMAN	Y		Subtract accumulator from memory, results to accumulator. If no borrow, one to status.
	IMAC	Y		Increment memory and load into accumulator. If carry, one to status.
	DMAN	Y		Decrement memory and load into accumulator. If no borrow, one to status.
	IAC	Y		Increment accumulator. If carry, one to status.
	DAN	Y		Decrement accumulator. If no borrow, one to status.
	A2AAC	Y		Add 2 to accumulator. Results to accumulator. If carry, one to status.
	A3AAC	Y		Add 3 to accumulator. Results to accumulator. If carry, one to status.
	A4AAC	Y		Add 4 to accumulator. Results to accumulator. If carry, one to status.
	A5AAC	Y		Add 5 to accumulator. Results to accumulator. If carry, one to status.
	A6AAC	Y		Add 6 to accumulator. Results to accumulator. If carry, one to status.
	A7AAC	Y		Add 7 to accumulator. Results to accumulator. If carry, one to status.
	A8AAC	Y		Add 8 to accumulator. Results to accumulator. If carry, one to status.
	A9AAC	Y		Add 9 to accumulator. Results to accumulator. If carry, one to status.
	A10AAC	Y		Add 10 to accumulator. Results to accumulator. If carry, one to status.
	A11AAC	Y		Add 11 to accumulator. Results to accumulator. If carry, one to status.
	A12AAC	Y		Add 12 to accumulator. Results to accumulator. If carry, one to status.
	A13AAC	Y		Add 13 to accumulator. Results to accumulator. If carry, one to status.
	A14AAC	Y		Add 14 to accumulator. Results to accumulator. If carry, one to status.
	IYC	Y		Increment Y register. If carry, one to status.
	DYN	Y		Decrement Y register. If no borrow, one to status.
	CPAIZ	Y		Complement accumulator and increment. If then zero, one to status.

— CONTINUED —

TABLE 4
TMS 1100/1300 STANDARD INSTRUCTION SET (Continued)

FUNCTION	MNEMONIC	STATUS EFFECT		DESCRIPTION
		C	N	
Arithmetic Compare	ALEM	Y		If accumulator less than or equal to memory, one to status.
Logical Compare	MNEA		Y	If memory is not equal to accumulator, one to status.
	MNEZ		Y	If memory not equal to zero, one to status.
	YNEA		Y	If Y register not equal to accumulator, one to status and status latch.
	YNEC		Y	If Y register not equal to a constant, one to status.
Bits in Memory	SBIT			Set memory bit
	RBIT			Reset memory bit
	TBIT1		Y	Test memory bit. If equal to one, one to status.
Constants	TCY			Transfer constant to Y register
	TCMIY			Transfer constant to memory and increment Y
Input	KNEZ		Y	If K inputs not equal to zero, one to status.
	TKA			Transfer K inputs to accumulator
Output	SETR			Set R output addressed by Y
	RSTR			Reset R output addressed by Y
	TDO			Transfer data from accumulator and status latch to O-outputs
RAM X Addressing	LDX			Load X with file address
	COMX			Complement the MSB of X
ROM Addressing	BR			Branch on status = one
	CALL			Call subroutine on status = one
	RETN			Return from subroutine
	LDP			Load page buffer with constant
	COMC			Complement chapter

NOTES: C-Y (Yes) means that if there is a carry out of the MSB, status output goes to the one state. If no carry is generated, status output goes to the zero state.

N-Y (Yes) means that if the bits compared are not equal, status output goes to the one state. If the bits are equal status output goes to the zero state.

A zero in status remains through the next instruction cycle only. If the next instruction is a branch or call and status is a zero, then the branch or call is not executed successfully.

4.3 RAM OPERATION

The TMS 1100/1300 devices contain a 512-bit RAM for data storage. The matrix consists of eight files, each file containing 16 four-bit words. Similar to the TMS 1000/1200, the X and Y registers address the RAM. The Y register selects one of the 16 words in a file and the X register (three bits long) selects one of eight possible files. When using the set or reset R instructions, the X register must be less than four.

4.4 OUTPUT

The TMS 1100 is pin-for-pin interchangeable with the TMS 1000 and contains eleven R outputs and eight O outputs.

The R-output capability in the TMS 1300 is increased to 16 output latches. These extra latches perform control functions directly that would have required external decoding logic in the TMS 1100 device. These additional R outputs can be set to any combination. For example, Figure 2 shows an O-output data bus going into the transmitter section of the UART. If the O-output PLA is programmed to send out four bits of binary data (when directed to do so by the status latch), then three additional R outputs connected to the UART transmitter input provides the user with full seven-bit ASCII output capability.

5. TMS 1400/1600 AND TMS 1470/1670 MICROCOMPUTERS

5.1 ROM ORGANIZATION/CHAPTER CONTROL

The sequence of the 4096 eight-bit ROM instructions determines the device operation. Instruction ROM contains four chapters of 16 pages each. A page contains 64 eight-bit words. After power-up the program execution starts at a fixed instruction address. A shift-register program counter sequentially addresses each ROM instruction on a page. A conditional branch or call subroutine instruction may alter the six-bit program-counter address to transfer software control. Three levels of subroutine return address may be stored in the subroutine return register.

The page address register (four bit) holds the current address for one of the 16 ROM pages. To change pages, a constant from ROM loads into the page buffer register (four bits), and upon a successful branch or call, the page buffer loads into the page address register. The page subroutine register, which is a three-level stack, holds the return page address in the call subroutine mode.

The chapter logic consists of three control registers, chapter address, chapter buffer, and chapter subroutine with a three level stack. The chapter buffer data is controlled by the TPC instruction, which transfers the page buffer to the chapter buffer. The chapter buffer transfers into the current chapter address if a branch or call executes successfully. If a call is successful, the return chapter is saved in a chapter subroutine latch.

5.2 RAM OPERATION

There are 512 addressable bits of RAM storage. The RAM is composed of eight files, each containing 16 four-bit words. The RAM is addressed by the X and Y registers. The Y register selects one of the 16 words in a file and is completely controllable by the ALU. The TMS 1000 Family has instructions within the standard instruction set that compare Y to a constant, set Y to a constant, increment or decrement Y, and/or perform data transfer to or from Y. Three bits in the X register select one of the eight 16-word files. The X register is set to a constant or is complemented. A four-bit data word goes to the RAM location addresses by X and Y from the accumulator or from the constants in the ROM. The RAM output words go to the ALU and can be operated on and loaded into Y or the accumulator in one instruction interval. Any selected bit in the RAM can be set, reset, or tested.

5.3 TMS 1400/TMS 1470 DATA INPUT

There are four data inputs to the TMS 1400/TMS 1470 circuit: K1, K2, K4 and K8 (see Figure 10). Each time an input word is requested, the data path from the K-inputs is enabled to the adder. The inputs are either tested for a high level ($\approx V_{SS}$) or the input data is stored in the accumulator for future use. The R-outputs usually multiplex inputs such as keys and other data onto the K-input lines. Other input interfaces are possible. Data from the K-inputs can be stored periodically in synchronization with the predetermined data rate of the external device. Thus, multiple four-bit words can be requested and stored with only one R-output supplying the control signal.

5.4 TMS 1600/TMS 1670 DATA INPUT

The TMS 1600/TMS 1670 devices have eight data inputs: K1, K2, K4, K8 and L1, L2, L4, L8 (see Figure 11). These two ports are multiplexed internally into a four-bit input bus. In addition, the TMS 1600/TMS 1670 have two control inputs: the K/L selector and SE Mode Selector. The K/L control has an internal pull-down resistor so that when no input is applied, or when the K/L input is at low level, the K-input is selected.

When the K/L input is at a high level, the four-bit L-input port is selected. The L-input port has two modes: a pass mode and a sense mode. The SE Mode Selector input has an internal pull-down resistor, and normally the pass mode is selected. When the SE Mode Selector is at a high level, the sense mode is selected. During sense mode, positive momentary inputs are latched. Table 5 summarizes functions of K/L and SE Mode Selector inputs. K/L selects requires one instruction setup time minimum.

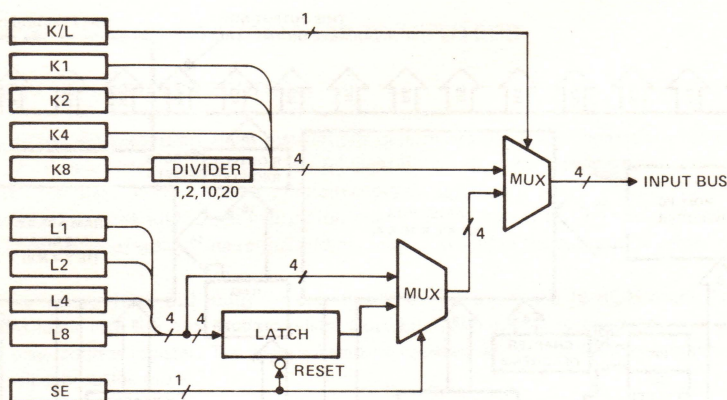


FIGURE 11 – TMS 1600/TMS 1670 INPUT BUS CONFIGURATION

TABLE 5
K/L SELECTOR AND SE MODE SELECTOR FUNCTIONS
(TMS 1600/TMS 1670 ONLY)

K/L SELECTOR	SE MODE SELECTOR	OPERATION
0	0	K-Input Data to Input Bus Latches are Reset
0	1	K-Input Data to Input Bus Latches are Active
1	0	L-Input Data to Input Bus Latches are Reset
1	1	L-Latch Data to Input Bus Latches are Active

5.5 K8 FREQUENCY DIVIDER

A frequency divider has been incorporated into the K8 input. Any one of four options (K8 direct pass, divided by factors of 2, 10, or 20) can be defined during device manufacture. This count is reset when the INIT signal goes to a high level.

5.6 DATA OUTPUT

All devices in the TMS 1400 PMOS series have two types of output channels, each of which have multiple purposes: the R-outputs and the O-outputs. The R-outputs are addressed by the Y-register and each output can be set or reset individually. The eight parallel O-outputs come from a five-bit-to-eight-bit code converter, which is the O-output PLA.

5.7 R-DATA OUTPUT

There are eleven R-outputs for the TMS 1400, ten for the TMS 1470, and sixteen for the TMS 1600/TMS 1670. The R-outputs are addressed by the Y-register. (The R addressing is not affected by the X register.)

The R-outputs are typically used to multiplex inputs and strobe O-output data to displays, external memories, and other devices. Additionally one R-output can strobe other R-outputs that represent variable data, since every R-output may be set or reset individually. For example, the Y register addresses each latch in turn; the variable data R-outputs are set or reset; and finally, the data strobe R-latch is set.

5.8 O-DATA OUTPUT

The internally latched eight parallel O-outputs may be used for a wide variety of applications: driving displays, driving speakers, communicating with external memories or processors, and a host of other functions. Thirty-two unique eight-bit patterns can be configured by the user.

5.9 DEVICE SOFTWARE OPERATION

5.9.1 Instruction Set

The TMS 1400 series standard instruction set is identical to the TMS 1100 instruction set, however, in order to extend addressing into the four chapters of ROM, the complement chapter instruction (COMC) has been replaced by a transfer page buffer to chapter buffer (TPC) which moves the two least significant bits of the page address buffer into the chapter address buffer.

5.9.2 O-Output PLA

The user defines a five-bit-to-eight-bit converter, called the O-output PLA, which specifies the state of the O lines for a given input. The four bits of the accumulator, and the output of the status latch provide for 32 unique O-output, eight-bit patterns.

5.9.3 Subroutine Calls

The TMS 1400 PMOS series devices have a three-level subroutine stack, and long branches can be executed during any level of subroutine. Subroutines can be of any length. Long branches can be executed at any time. Figure 12 is a flow diagram of subroutine calls.

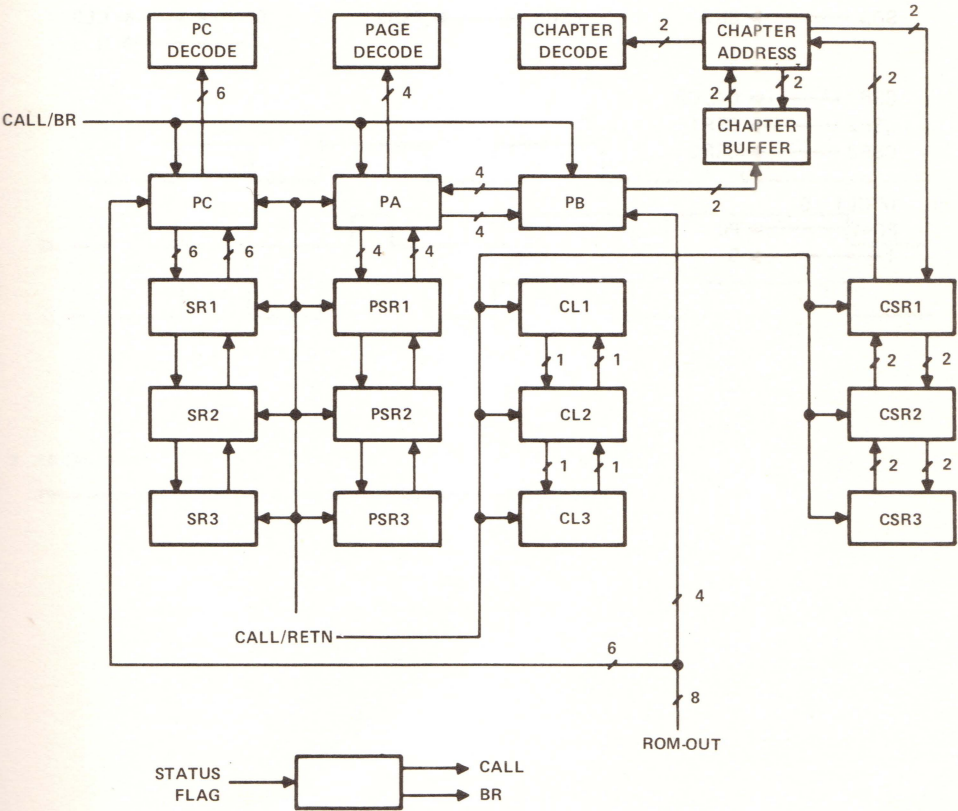
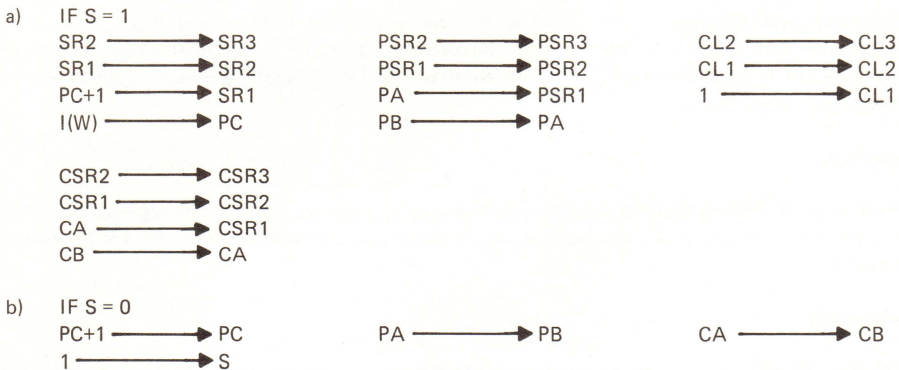
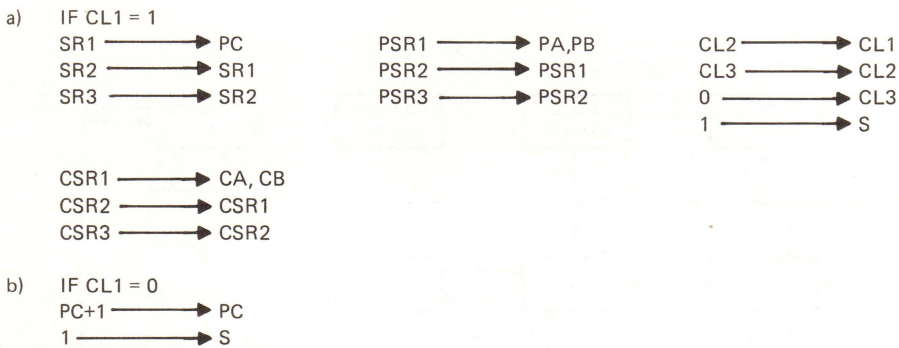


FIGURE 12 – SUBROUTINE/CALL FLOW

5.9.3.1 Action of Calls



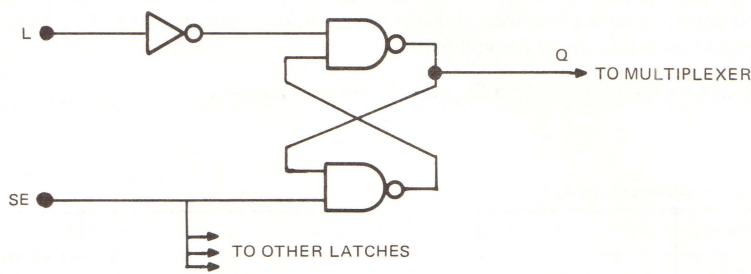
5.9.3.2 Action of RETN



5.10 TMS 1400 NOTES

1. LATCH CIRCUITRY

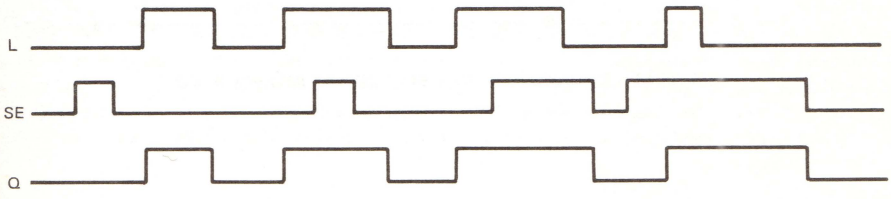
The latch circuitry at an input L is as follows:



This basically means that when (1) SE is low, Q follows L (i.e. the signal is passed)

(2) When SE is high, any high input on L is latched until SE goes low. If L is still high Q will remain high. If L had previously gone low and is still low, Q will not go low.

The following diagram shows what happens to Q for the various combinations of levels and pulses on L and SE.



2. K8 DIVIDER

There are divider options on K8. The division ratio can be 1, 2, 10 or 20.

6. TMS 1X70 MICROCOMPUTERS

6.1 INTRODUCTION

The TMS 1000 series flexibility is augmented by versions of high-voltage (35-volt) microcomputers the TMS 1X70. The standard instruction set and operation is identical to that of the TMS 1X00. Architecturally, the devices are identical to the TMS 1X00 except that two additional O-output OR-matrix terms were added to provide a total of ten O outputs in the TMS 1270, a 40-pin package unit. The TMS 1X70 provides direct interface to low-voltage fluorescent displays. The TMS 1X70 interfaces with all circuits requiring up to 35-volt levels.

Figure 13, shows an interface to a 30-volt fluorescent display.

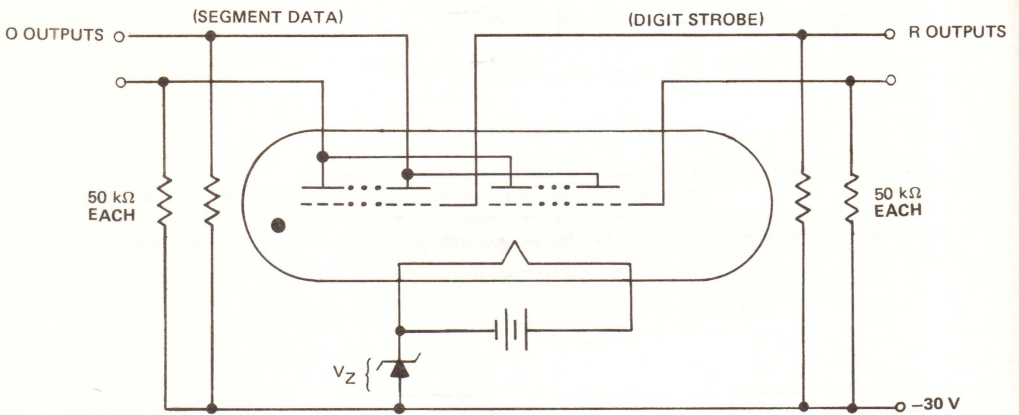


FIGURE 13 – STROBED FLUORESCENT DISPLAY INTERCONNECT

7. TMS 1X00 FAMILY POWER-UP AND INITIALIZATION (RESET)

7.1 INTRODUCTION

Power-up refers to when the power supply voltages are initially applied to the CPU. INITIALIZATION (RESET) is when the power supply voltage have already been applied and it's desired to restart program execution at the beginning of the algorithm.

7.2 POWER-UP

The TMS 1X00 family has the following two methods to clear the chip when the power supply voltages are properly applied.

7.2.1 Self-Contained Power-Up Latch

The TMS 1X00 family contains the internal power-up latch that automatically clears the chip at the time when power supply voltages are applied.

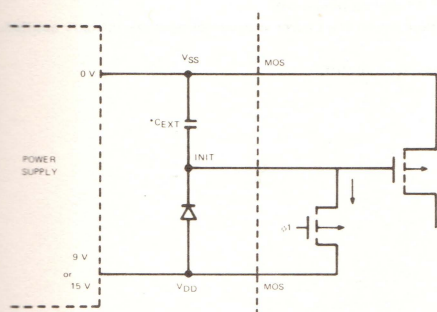
The power-up latch presets the program counter ($PC \leftarrow 0$), page address register and page buffer register (PA and $PB \leftarrow F_{16}$), and call latch ($CL \leftarrow 0$), as well as resetting O and R outputs registers to all ZEROes. Then program begins execution at fixed ROM address, $PA = F$, $PC = 0$. The RAM is not preset by power-up.

The system reset depends on the ROM program after the starting address.

One requirement of the internal power-up latch is that the power-up rise time must not exceed one millisecond.

7.2.2 INIT Input Pin

The INIT input can be used to override the internal power-up latch. This method is recommended because it can be made independent of the power-rise time requirement, thereby providing a more reliable power-up. As shown in Figure 14, to control power-up requires up to two external components, a capacitor and diode. To ensure this function, a minimum of $V_{SS}-1$ volt is applied to the INIT input when the power supply voltages are initially applied to the chip. CPU clear is active while the INIT input maintains voltage level of $V_{SS}-1$ volt. The INIT input must remain at logical "1" level for at least 1 ms from the time when the power supply voltages reach at V_{DD} min.



$$*C_{EXT} (\mu F) = (0.06) \times (\text{Power supply rise time (msec)})$$

CONDITIONS:

INIT

FUNCTIONS:

$PC \leftarrow 0$, PA , $PB \leftarrow F_{16}$

Reset O and R outputs registers to all ZEROes $CL \leftarrow 0$

FIGURE 14 – POWER-UP CLEAR BY INIT INPUT

7.3 Initialization (External Reset)

This function can be performed externally when the power supply voltages have already been applied. To perform an external reset the INIT input pin must remain within $V_{SS}-1$ volt for a minimum of six instruction cycles. Both the K-inputs and R-outputs must be logical "0" level for a minimum of six instruction cycles preceding INIT going logical "0" level. A switch can be used for manual reset.

Power-up clear and manual reset circuit examples are shown in Figure 15.

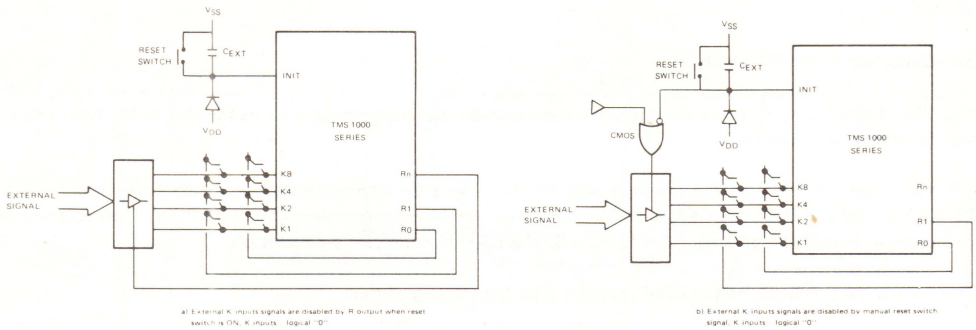


FIGURE 15 – EXAMPLE OF MANUAL RESET CIRCUIT
(Pull-down resistors are not shown on this circuit)

- NOTES:
1. While power-up function is active, O_7 outputs pulses that are not related by user's algorithm. Care must be taken for peripheral interface circuits.
 2. O -output register is reset to ZERO when power-up clear function is active, however, care must be taken for O -output because of user's defined O -output PLA code.
If user defines ZERO to AND term for output PLA definition card, PLA outputs (O -output(O_0-O_7)) are user's defined eight-bit output code during power-up clear.
For example:

$$\begin{array}{r} O_7 \ O_6 \ O_5 \ O_4 \ O_3 \ O_2 \ O_1 \ O_0 \\ \hline OUT(b) \ 00 = \\ 0 \ 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \end{array}$$

In this example, O -output, O_5 , O_4 , O_3 , O_2 , O_1 and O_0 are logical "1" during power-up.

3. The following conditions must be required to ensure power-up clear when the power supply voltages are initially applied.
 - K inputs must be stayed at logical "0" level.
 - R outputs must not be pulled up to logical "1" level by external circuit.

8. TMS TMS 1000 CMOS MICROPROCESSOR FAMILY

8.1 INTRODUCTION

The TMS 1000C, TMS 1200C, TMS 1100C, and TMS 1300C are family members of the TMS 1000-series of four bit microcomputers. These CMOS microcomputers are designed for applications requiring lower power and/or higher speed than can be achieved with the PMOS series devices. The TMS 1000C and TMS 1200C contain a 1024-word instruction ROM, 64-word RAM, and a four-bit arithmetic logic unit (ALU) on a single semiconductor chip. The TMS 1100C and the TMS 1300C contain a 2048-word instruction ROM, 128-word RAM, and a four-bit ALU on a single chip. The customer's specifications determine the software program to be imbedded in the ROM during chip manufacture. This unique characteristic is produced in wafer processing by changing a single-level mask pattern. The basic characteristics of the TMS 1000 CMOS Series are listed in Table 6.

The TMS 1100C is architecturally similar to the TMS 1000C, except that it contains twice the memory capacity – 16,384 bits of ROM and 512 bits of RAM. The instruction set for the TMS 1100C, shown in Table 4, is identical to the TMS 1100 PMOS instruction set.

The TMS 1300C is an expanded I/O version of the TMS 1100, with input/output features identical to the TMS 1200 CMOS. The TMS 1300C has two 4-bit input ports, 16 individually addressable R lines, and 8 parallel O lines.

TABLE 6 – TMS 1000 CMOS SERIES FEATURES

	TMS 1000C	TMS 1200C	TMS 1100C	TMS 1300C
Package Pin Count	28 Pins	40 Pins	28 Pins	40 Pins
Instruction Read Only Memory	1024 X 8 Bits (8,192 Bits)		2048 X 8 Bits (16,384 Bits)	
Data Random Access Memory	64 X 4 Bits (256 Bits)		128 X 4 Bits (512 Bits)	
Input/Sense Input	4/0	8/4	4/0	8/4
"R" Individually Addressed Output Latches	10	16	10	16
"O" Parallel Latched Data Outputs Latches	8 Bits			
Working Registers	24 Bits Each			
Standard Instruction Set	See Table 3		See Table 4	
HALT Mode (Power Down)			Yes	
On-Chip Oscillator			Yes	
Power Supply/Typical Dissipation	5 V/3.5 mW		5 V/5 mW	

8.2 TIMING RELATIONSHIPS AND OSCILLATOR OPERATION

Six clock pulses constitute one instruction cycle. The actual machine cycle period is determined by either a fixed external resistor and capacitor connected to the OSC1 and OSC2 pins, or an external clock input frequency.

If the internal oscillator is used, OSC1 and OSC2 are connected with a resistor; and a capacitor is connected between OSC1 and V_{SS} . The frequency of operation for given components is shown in Figure 41. The current drain I_{DD} is greatly affected by the resistor selected; hence for lowest power consumption a resistor greater than 10K ohms is recommended, and the user should select a capacitor value for the desired clock frequency.

If an external clock is desired, the clock source should be connected to OSC1. OSC2 should not be connected but allowed to float.

8.3 INITIALIZATION

Power-up refers to the initial application of the power supply voltage to the device. Reset consists of restarting program execution at the beginning of the algorithm any time after the initial power-up sequence.

The TMS 1000C/1200C power-up mode and reset mode differ only in that during power-up mode the K-inputs are in a don't care condition; whereas, during reset mode the K-inputs must be at zero level.

8.3.1 Power-Up

Initializing the TMS 1000C/1200C consists of resetting the page address register, the program counter and the O and R-outputs. The internal power-up latch will execute a power-up with no external components so long as the power-supply rise time does not exceed 300 μ sec. INIT must be tied to V_{SS} and no external components are needed. A circuit similar to Figure 16 may be used with slower power-supplies. Some of the components are optional depending upon the application.

8.3.2 External Reset

To perform an external reset the INIT-input pin must remain high for a minimum of six instruction cycles. The K-inputs must be low for a minimum of six instruction cycles preceding INIT going low, which resets the ROM address. While INIT is high, the O and R-outputs are reset.

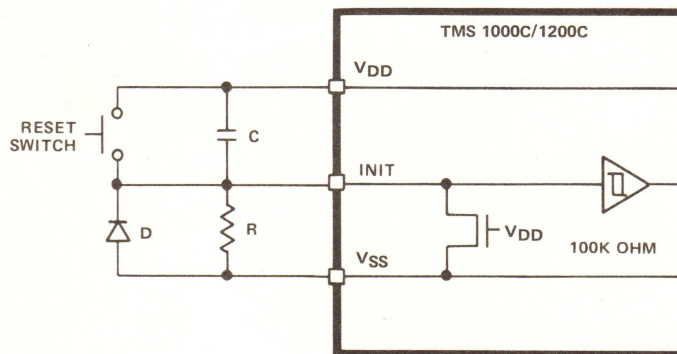


FIGURE 16 – TYPICAL RESET CIRCUIT

HALT

HALT is used to reduce power consumption in the standby state. Normal operation of the TMS 1000C/1200C devices requires 3.5 mW, but HALT mode typically consumes less than 0.5 μ W. This capability is advantageous for use in battery operated portable systems or battery/capacitor operated backup systems. The TMS 1000C/1200C goes into the HALT mode at the end of the machine cycle after the HALT-input is brought to a high level. Output lines are unaffected by the HALT mode. When HALT is returned to a low level, the TMS 1000C/1200C starts execution from the next program counter location. The HALT mode is normally a high impedance input and must be tied to V_{SS} if not used. When the INIT-pin is high the HALT-input is pulled low internally.

DATA INPUT

TMS 1000C Data Input

There are four data inputs to the TMS 1000C circuit: K1, K2, K4 and K8. Each time an input word is requested, the data path from the K-inputs is enabled to the adder. The inputs are either tested for a high level ($\approx V_{DD}$) or the input data is stored in the accumulator for future use. The R-outputs usually multiplex inputs such as keys and other data onto the K-input lines. Other input interfaces are possible. Data from the K-inputs can be stored periodically in synchronization with the predetermined data rate of the external device. Thus, multiple four-bit words can be requested and stored with only one R-output supplying the control signal.

TMS 1200C Data Input

The TMS 1200C device has eight data inputs: K1, K2, K4, K8 and L1, L2, L4, L8 (see Figure 17). These two ports are multiplexed internally into a four-bit bus. In addition, the TMS 1200C has two control inputs: the K/L selector and the SE Mode Selector. The K/L control input has an internal pull-down resistor so that when no input is applied or when the K/L input is a low level, the K-input is selected.

When the K/L input is at a high level, the four-bit L-input port is selected. The L-input port has two modes: a pass mode and a sense mode. The SE Mode Selector input has an internal pull-down resistor, and normally the pass mode is selected. When the SE Mode Selector is at a high level, the sense mode is selected. During sense mode, positive momentary inputs are latched. Table 7 summarizes functions of K/L and SE Mode Selector inputs.

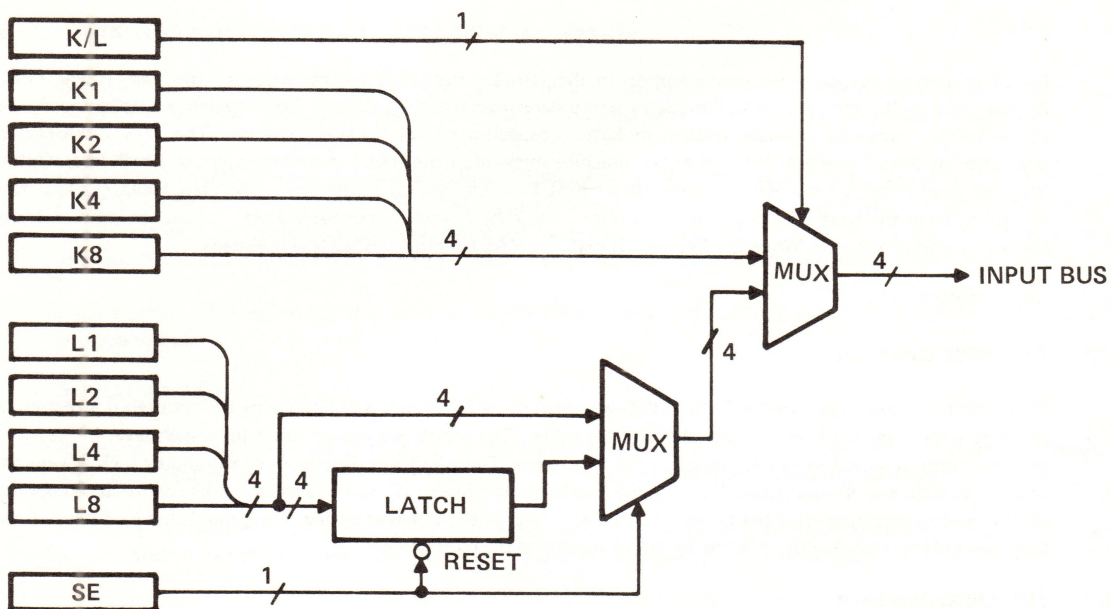


FIGURE 17 – TMS 1200C INPUT BUS CONFIGURATION

TABLE 7
K/L SELECTOR AND SE MODE SELECTOR FUNCTIONS
(TMS 1200C ONLY)

K/L SELECTOR	SE MODE SELECTOR	OPERATION
0	0	K-Input Data to Input Bus Latches are Reset
0	1	K-Input Data to Input Bus Latches are Active
1	0	L-Input Data to Input Bus Latches are Reset
1	1	L-Latch Data to Input Bus Latches are Active

10.6 DATA OUTPUT

Both devices have two output channels with multiple purposes: the R-outputs and the O-outputs. Ten (TMS 1000C) or sixteen (TMS 1200C) internal latches store the R-output data. The R-outputs are individually addressed by the Y register. Each addressed bit can be set or reset individually. The eight parallel latched O-outputs come from a five-bit-to-eight-bit code converter, which is the O-output PLA.

10.6.1 R-Data Output

The R-outputs are typically used to multiplex inputs and strobe O-output data to displays, external memories, and other devices. Also, one R-output can strobe other R-outputs that represent variable data, because every R-output may be set or reset individually. For example, the Y register addresses each latch in turn; the variable data R-outputs are set or reset; and finally, the data strobe R-latch is set.

10.6.2 O-Data Output

The internally latched eight parallel O-outputs may be used for a wide variety of applications: driving displays, driving speakers, communicating with external memories or processors, and hosts of other functions. Thirty-two unique eight-bit patterns can be configured by the user.

10.7 INSTRUCTION SETS

10.7.1 Standard Instruction Set

Table 3 defines the TMS 1000C/1200C standard instruction set with description, mnemonic, and status effect. The instruction mnemonics are identical to the TMS 1000/1200 PMOS series which are intended for easy reference to the functional description. Most routines may be transferred from the PMOS to the CMOS device with minimal changes.

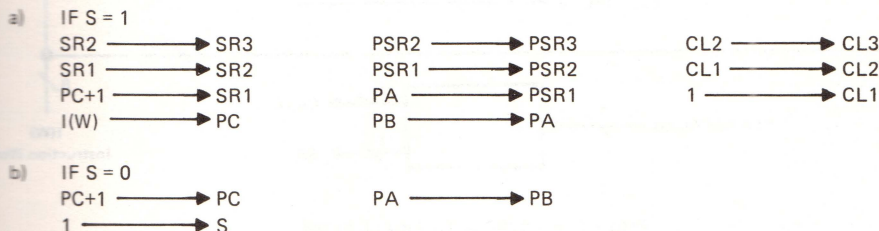
10.8 O-OUTPUT PLA

The user defines a five-bit-to-eight-bit converter, called the O-output PLA, which specifies the state of the O lines for a given input. The four bits of the accumulator, and the output of the status latch provide for 32 unique O-output, eight-bit patterns.

10.9 SUBROUTINE CALLS

The TMS 1000C/1200C devices have a three-level subroutine stack, and long branches can be executed during any level of subroutine. Subroutines can be of any length and are not restricted to 64 words as is the case with the TMS 1000/1200 PMOS series. Long branches can be executed at any time. Figure 18 is a flow diagram of subroutine calls.

10.9.1 Action of Call



3.5 DATA OUTPUT

Both devices have two output channels with multiple purposes: the R-outputs and the O-outputs. Ten (TMS 1000C) or sixteen (TMS 1200C) internal latches store the R-output data. The R-outputs are individually addressed by the Y register. Each addressed bit can be set or reset individually. The eight parallel latched O-outputs come from a five-bit-to-eight-bit code converter, which is the O-output PLA.

3.5.1 R-Data Output

The R-outputs are typically used to multiplex inputs and strobe O-output data to displays, external memories, and other devices. Also, one R-output can strobe other R-outputs that represent variable data, because every R-output may be set or reset individually. For example, the Y register addresses each latch in turn; the variable data R-outputs are set or reset; and finally, the data strobe R-latch is set.

3.5.2 O-Data Output

The internally latched eight parallel O-outputs may be used for a wide variety of applications: driving displays, driving speakers, communicating with external memories or processors, and hosts of other functions. Thirty-two unique eight-bit patterns can be configured by the user.

3.7 INSTRUCTION SETS

3.7.1 Standard Instruction Set

Table 3 defines the TMS 1000C/1200C standard instruction set with description, mnemonic, and status effect. The instruction mnemonics are identical to the TMS 1000/1200 PMOS series which are intended for easy reference to the functional description. Most routines may be transferred from the PMOS to the CMOS device with minimal changes.

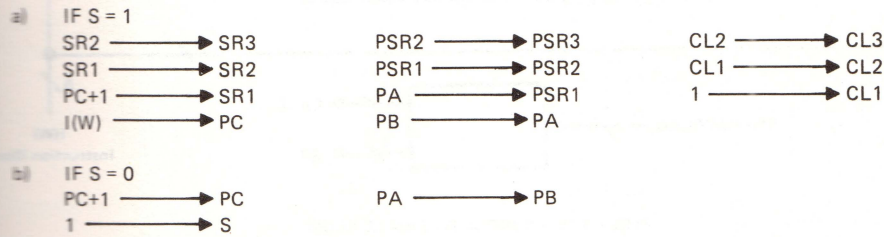
3.8 O-OUTPUT PLA

The user defines a five-bit-to-eight-bit converter, called the O-output PLA, which specifies the state of the O lines for a given input. The four bits of the accumulator, and the output of the status latch provide for 32 unique O-output, eight-bit patterns.

3.9 SUBROUTINE CALLS

The TMS 1000C/1200C devices have a three-level subroutine stack, and long branches can be executed during any level of subroutine. Subroutines can be of any length and are not restricted to 64 words as is the case with the TMS 1000/1200 PMOS series. Long branches can be executed at any time. Figure 18 is a flow diagram of subroutine calls.

3.9.1 Action of Call



8.9.2 Action of RETN

- a) CL1 = 1
 SR1 → PC
 SR2 → SR1
 SR3 → SR2
- PSR1 → PA
 PSR2 → PSR1
 PSR3 → PSR2
 PA → PB
- CL2 → CL1
 CL3 → CL2
 0 → CL3
 1 → S
- b) CL1 = 0
 PC+1 → PC
 1 → S

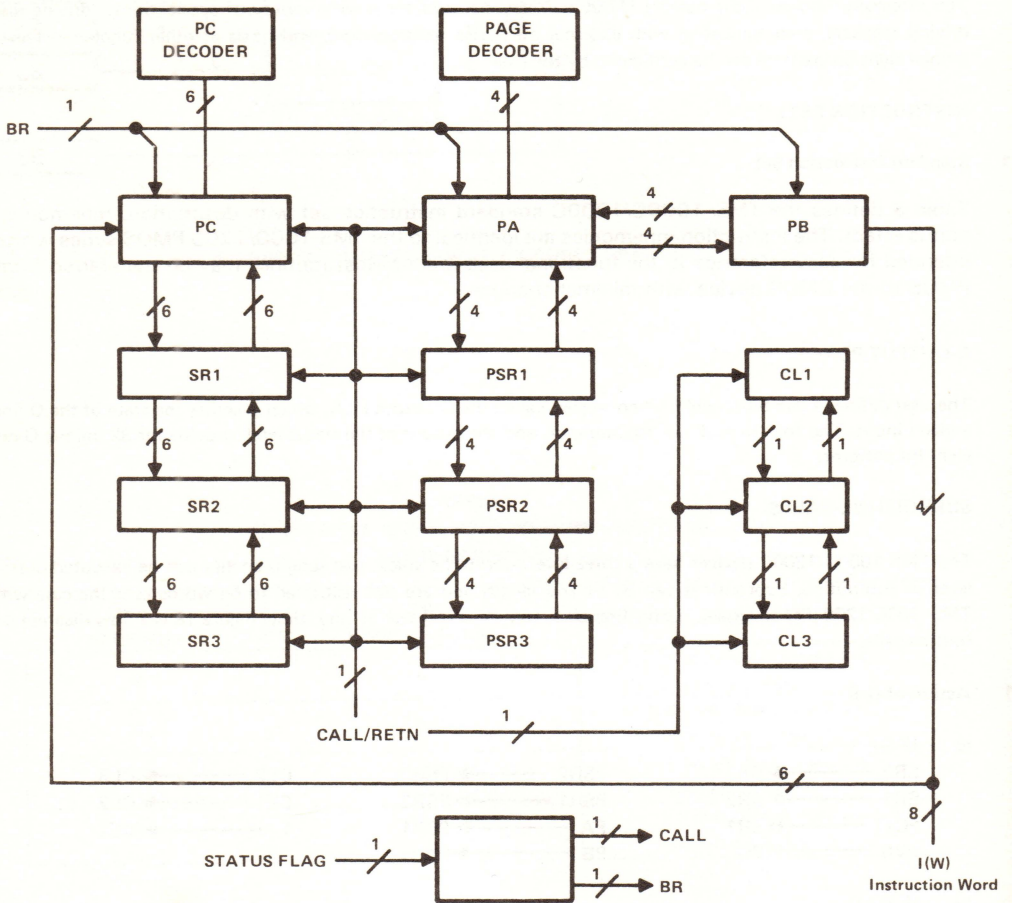


FIGURE 18 – SUBROUTINE/CALL FLOW

3.10 FUTURE CMOS SERIES PRODUCTS

Future products in the CMOS Series will offer outputs that interface to the high-voltage required for displays. These devices will be software compatible with the standard CMOS products, but will be manufactured with both inputs and outputs which can withstand 25 V. Features of these devices are outlined below:

Feature	Device	
	1070C	1270C
Output Voltage (Note 1)	-25V	-25V
Package Pin Count	28	40
Instruction ROM	1K x 8	1K x 8
Data RAM	64 x 4	64 x 4
K/L Inputs	4/0	4/4
R Lines	10	16
O Lines	8	8
Power Supply & Dissipation	5V/5mW	5V/5mW
Maximum Oscillator Frequency	1MHz	1MHz
Temperature Range	0°-70°C	0°-70°C
Software Evaluator With External Instruction Memory	SE 1000C	SE 1000C
AMPL 1000	YES	YES

NOTE 1: For the VF version, with appropriate current limiting, the absolute maximum supply voltage that may be applied to the output terminal at $V_{DD} = 5V$.

9. MICROCOMPUTER SYSTEM EVALUATORS

9.1 SE-1000P, SE-1100P, AND SE-1400

9.1.1 Introduction

The SE-1000P, SE-1100P and SE-1400 are functionally identical to the TMS 1000/1200, TMS 1100/1300 and TMS 1400/1600 respectively when combined with external memory. The system evaluators are ideally suited for prototype fabrication and field testing. Costly program delays can be eliminated by testing algorithms thoroughly before submitting the final code to Texas Instruments for manufacturing. There are System Evaluation Boards (SEBs) for each evaluator which have the EPROM/OPLA PROM/I/O buffering all in one for use in prototype demonstrations. Table 8 summarizes the functions of each evaluator.

TABLE 8 – SYSTEM EVALUATORS

	SE-1000P	SE-1100P	SE-1400
TMS Number	TMS 1099 JL	TMS 1098 JL	TMS 1097 JLL
Simulates Microcomputer (instruction set)	TMS 1000/1200 TMS 1700 TMS 1070/1270	TMS 1100/1300 TMS 1170/1370	TMS 1400/1600 TMS 1470/1670
Maximum ROM address	1024 X 8 Bits/Word	2048 X 8 Bits/Word	4096 X 8 Bits/Word
O outputs	5	5	5
Maximum R outputs	16	16	16
Single Power Supply	Yes - 15 V	Yes - 15 V	Yes - 9 V
Internal or external oscillator	Yes	Yes	Yes

9.1.2 Operation

When the system evaluators are combined with external instruction memory, their operation is identical to their respective TMS 1000 series devices. A dedicated parallel-instruction address selects the instruction word that transfers into the system evaluator through a dedicated eight-bit-parallel input. Therefore, the user does not need external timing or multiplexing circuits.

To store the program Texas Instruments provides a variety of memory products including the TMS 2708/2716 and the TMS 2508/2516. All of these EPROMs can be conveniently programmed using the AMPL1000 PROM programming board. (See Section 10).

The system evaluators O-output Programmable Logic Array (PLA) transfers the five-bit O-register contents directly to the five O outputs, O1, O2, O4, O8, and OSL.

If the system evaluators are used to emulate the TMS 1000/1100 series devices, the user must remember that the O-output PLA has a maximum of 20 product terms. Refer to the O-output PLA description in the *TMS 1000 Family Design Manual* for details.

Figures 19 and 20 show typical configurations with the system evaluators in prototyping systems.

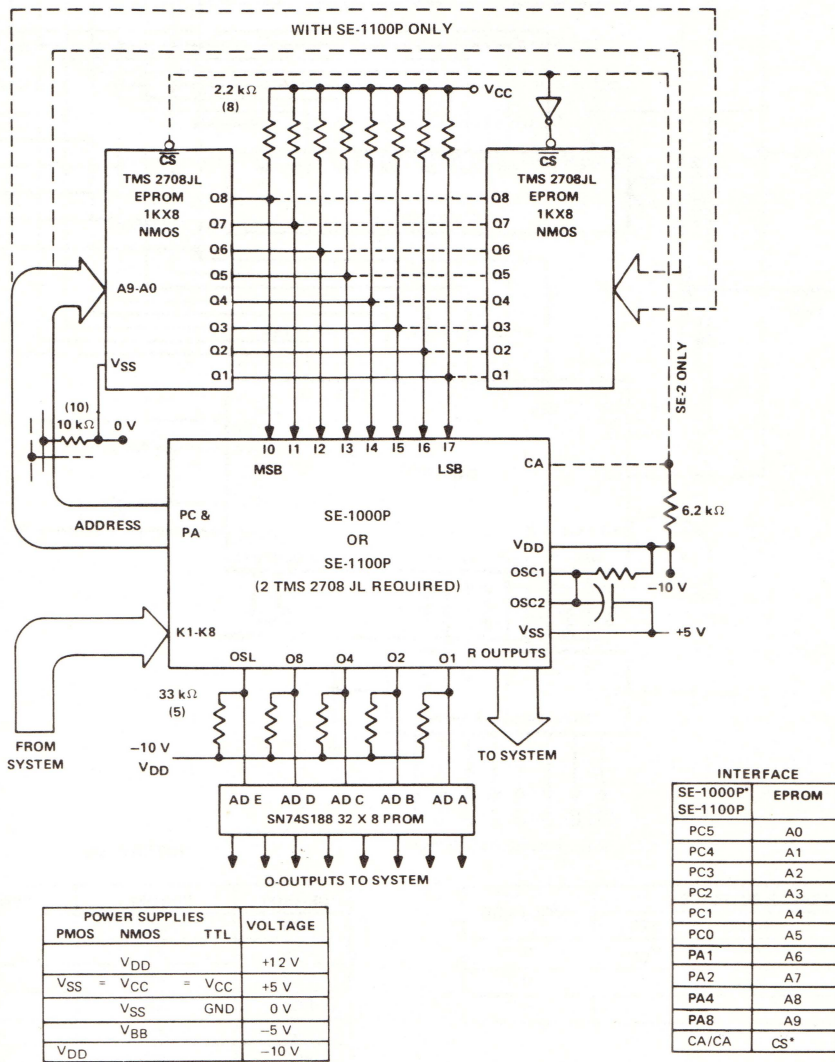
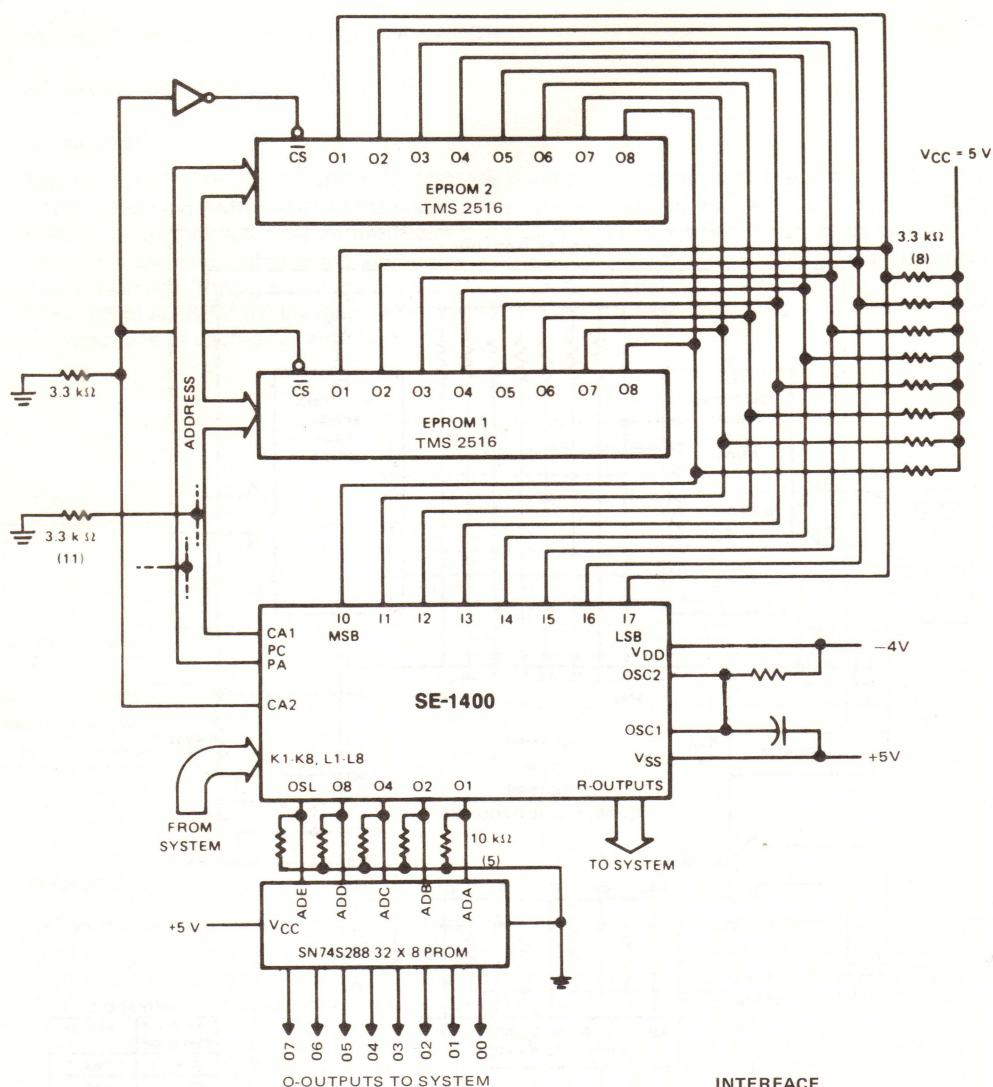


FIGURE 19 – BLOCK DIAGRAM OF TYPICAL APPLICATION-PROTOTYPING SYSTEM WITH SE-1000P OR SE-1100P



INTERFACE

POWER SUPPLIES			VOLTAGE
PMOS	NMOS	TTL	
V_{SS}	V_{CC}	V_{CC}	+5 V
	V_{SS}		0 V
V_{DD}			-4 V

SE-1400	EPROM 1	EPROM 2
PC5	A0	A0
PC4	A1	A1
PC3	A2	A2
PC2	A3	A3
PC1	A4	A4
PC0	A5	A5
PA1	A6	A6
PA2	A7	A7
PA4	A8	A8
PA8	A9	A9
CA1	A10	A10
CA2	CS	NC
CA2	NC	CS

FIGURE 20 — BLOCK DIAGRAM OF TYPICAL APPLICATION — PROTOTYPING SYSTEM FOR SE-1400

9.1.3 Special SE-1400 Pins Useful for Debugging

The SE-1400 contains a number of status and control lines not found in the TMS 1400 series that are used in addressing the external memory and showing internal status:

- X1, X2, X4 X Register with X4 the MSB
- $\phi 1$ Output signal of internal $\phi 1$ clock
- ST Accumulator status output signal
- PC0 – PC5 ROM Program Counter Outputs with PC0 the MSB
- PA1 – PA8 ROM Program Counter Outputs with PA8 the MSB
- CA1 – CA2 Chapter Address Outputs with CA2 the MSB
- I0 – I7 External-Memory Instruction inputs with I0 the MSB
- DS1, DS2 Divider Select inputs which allow the user to select the divide function for K8. Selection is made as shown in Table 9.

TABLE 9 – K8 DIVIDER OPTIONS

DS2	DS1	DIVIDER SELECTION
0	0	1
0	1	1/2
1	0	1/10
1	1	1/20

9.2 SE-1000C AND SE-1100C

9.2.1 Introduction

The SE-1000C and SE-1100C are functionally identical to the TMS 1000C/1200C and the TMS 1100C/1300C respectively when combined with external instruction memory. The system evaluators are ideally suited for prototype development, field testing, and limited production volumes requiring field programmability. Costly program delays can be eliminated by testing algorithms thoroughly with the evaluators before submitting the final code to Texas Instruments for manufacturing.

The SE-1100C is the System Evaluator for the TMS 1100/1300 CMOS devices. It is functionally identical to the SE-1000C with the following exceptions:

- Pin 54 is changed from no connection to CA, which is used to select the ROM chapter.
- Pin 55 is changed from no connection to X4, and this signal is used to address the additional RAM on the SE-4.
- Pin 6 is changed from CLR to $\overline{\text{HALTSE}}$. This signal allows emulation of the HALT signal. If $\overline{\text{HALTSE}}$ is at a high logic level, all outputs will be enabled. If $\overline{\text{HALTSE}}$ is at a low logic level, all outputs go to a high impedance, except for R0, R1, R14, and R15, which do not change when $\overline{\text{HALTSE}}$ goes low.

9.2.2 Operation

The program is stored in an external memory. This is best handled by a TMS 2508/2516 EPROM for most checkout/debug operations. The EPROM is addressed by ten bits PA0, . . . PA3, PC0, . . . PC5 where PA0 is the MSB and PC5 is the LSB. The instruction word from the EPROM is returned to IO, . . . I7 where IO is the MSB. The EPROM can be programmed very easily using an AMPL PROM programmer.

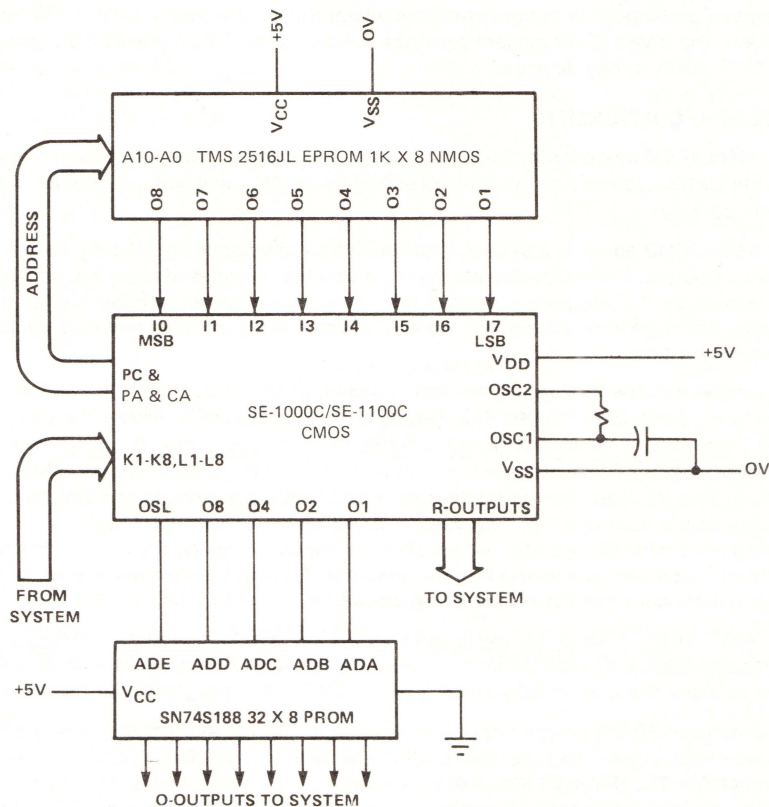
The O-output port on the SE devices is brought out undecoded as O1, O2, O4, O8, and OSL. Various devices are available that can emulate the O-output PLA coding on the TMS 1000C/1200C devices. If seven-segment displays are used, an SN7448, SN7449, or equivalent may be used. For more general decoding an SN74188 or SN74288 (organized as 32 X 8) provides the code conversion. The CMOS O-output PLA provides a full 32-term decode to the 8 output lines.

Figure 21 shows a typical configuration using either the SE-1000C or SE-1100C system evaluator in a prototyping system.

9.2.3 Special SE-1000C/1100C Pins Useful For Debugging

The SE-1000C/1100C contain a number of status and control lines not found in the TMS 1000C/1200C/1100C/1300C which are useful in program debugging:

X1, X2	X Register with X2 the MSB
YA, YB	The four bits of the Y Register may be multiplexed out on YA and YB. The data may be accessed with a TP4013 type latch and the internal phase clock $\phi 1$. The rising edge of $\phi 1$, clock can latch Y8 (MSB) from YB and Y4 from YA. The falling edge of $\phi 1$ clock can latch Y2 from YB and Y1 from YA.
$\phi 1$	Output signal of internal $\phi 1$, clock
ST	Accumulator status output signal
CLR	When set to a logical 1, a CLO instruction clears the R-outputs. When set to a logical 0, a CLO instruction clears the O-outputs
PC0 – PC5	ROM Program Counter Outputs with PC0 the MSB
PA0 – PA3	ROM Page-Address Outputs with PA0 the MSB
IO – I7	External-Memory Instruction inputs with IO the MSB



INTERFACE

POWER SUPPLIES			VOLTAGE
CMOS	NMOS	TTL	
V _{DD}	V _{CC}	V _{CC}	+5 V
V _{SS}	V _{SS}	GND	0 V

SE-1000C/1100C	EPROM
PC5	A0
PC4	A1
PC3	A2
PC2	A3
PC1	A4
PC0	A5
PA3	A6
PA2	A7
PA1	A8
PA0	A9
CA	A10

FIGURE 21 — BLOCK DIAGRAM OF TYPICAL APPLICATION — PROTOTYPING SYSTEM WITH SE-1000C OR SE-1100C

10. AMPL1000 DEVELOPMENT SYSTEM SUPPORT

10.1 INTRODUCTION

The TMS 1000 family of microprocessors is supported by the AMPL1000 line of development systems. This line provides the highest performance system at the lowest cost in the history of the TMS 1000 device. The AMPL1000 system consists of a real-time in-circuit emulator with editor, assembler and emulator control software which run on the user's TMS 9900-based minicomputer. In addition, the AMPL1000 system provides the user with PROM and EPROM programming support for the TMS 1000 family devices.

10.2 AMPL1000 COMPONENTS

The AMPL1000 system may be broken down into software and hardware components. The software provided is a completely self-contained editor, assembler, and emulator control system incorporated into one package.

The AMPL1000 editor is a syntax-checking editor developed specifically for the TMS 1000 family of microcomputers. The editor detects syntax errors (i.e. misspelled opcodes, operands out of range, etc.) and generates the program's symbol table while the user is entering his source code. This greatly reduces the number of assembly-time errors which are generated and consequently reduces program development time.

The emulator software controls the downloading of object code into the actual AMPL1000 emulator, and allows the user to monitor the execution of his program. It allows the user to run, slow-step and trace his program, as well as giving him the ability to easily modify the internal machine state of the emulator. Figure 22 illustrates the information presented in a typical AMPL1000 Machine State Display. This includes the internal registers and RAM, the outputs and inputs, and a five-line window into the user's source code. The values of the emulator's internal registers may be modified by activating a Machine State Editor, which allows the user to change the fields of the Machine State Display and then load these new values into the emulator. As with the source-code editor, changes are checked to be syntactically correct before being stored.

The AMPL1000 system hardware consists of the emulator board, a PROM programmer/download board, and host and target system cables. The emulator board works with the above mentioned software to allow the user to fully check out his TMS 1000 program with his target system.

The download/PROM programmer board supplied with the system provides the interface between the TI host minicomputer and the AMPL1000 emulator. In addition, PROM programming capabilities are provided for TI's TMS 27XX series EPROMs, TMS 25XX series EPROMs and 74S288 fuse-link PROMs. Custom interactive software is provided with this board to make PROM programming fast and simple.

11. TMS 1000, 1100, 1200, 1300, 1700 (15 VOLT SERIES NLP) ELECTRICAL SPECIFICATIONS

Specifications listed under Absolute Maximum Ratings are stress ratings only and functional operation of the device at any conditions beyond those listed in the Recommended Operating Conditions is not implied, and may cause permanent damage to the device. The Recommended Operating Conditions are those recommended by the manufacturer for normal device functions. The Electrical Characteristics list the specifications by which the device is tested to perform reliably.

11.1 TMS 1000, 1100, 1200, 1300, 1700 (15 VOLT SERIES NLP) ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE (UNLESS OTHERWISE NOTED)

TMS 1000, 1100, 1200, 1300, 1700 (15 VOLT SERIES NLP)

Supply Voltage, V_{DD} (See Note 1)		- 20V to 0.3V
Data Input Voltage		- 20V to 0.3V
Clock Input and INIT Voltage		- 20V to 0.3V
Average Output Current (See Note 2)	O Outputs	- 24mA
	R Outputs	- 14mA
Peak Output Current (See Note 3)	O Outputs	- 48mA
	R Outputs	- 28mA
Continuous Power Dissipation	1000, 1100, 1700	400mW
	1200, 1300	600mW
Operating free-air temperature range		0°C to 70°C
Storage temperature range		- 55°C to 150°C

- NOTES: 1. Unless otherwise noted, all voltages are with respect to V_{SS} .
2. These average values apply for any 100 ms period.
3. Use of multiple outputs at the maximum ratings may violate the I_{SS} capability of the device. Contact Texas Instruments concerning applications of this type.

11.2 TMS 1000, 1100, 1200, 1300, 1700 (15 VOLT SERIES NLP) RECOMMENDED OPERATING CONDITIONS

TMS 1000, 1100, 1200, 1300, 1700 (15 VOLT SERIES NLP)

PARAMETER		MIN	NOM	MAX	UNIT
Supply Voltage, V_{DD} (See Note 1)		- 14	- 15	- 17.5	V
High-Level Input Voltage, V_{IH} (See Note 2)	K	- 1.3	- 1	0.3	V
	INIT or CLOCK	- 1.3	- 1	0.3	
Low-Level Input Voltage, V_{IL} (See Note 2)	K	V_{DD}		- 4	V
	INIT or CLOCK	V_{DD}	- 15	- 8	
Clock Cycle Time, $t_{C(\phi)}$		2.5	3	10	μS
Instruction Cycle Time, t_c		15		60	μS
Pulse Width, Clock High, $t_{w(\phi H)}$		1			μS
Pulse Width, Clock Low, $t_{w(\phi L)}$		1			μS
Sum of Rise Time and Pulse Width, Clock High, $t_r + t_{w(\phi H)}$		1.25			μS
Sum of Fall Time and Pulse Width, Clock Low, $t_f + t_{w(\phi L)}$		1.25			μS
Oscillator Frequency, f_{OSC} (See Note 3)		100		400	kHz
Operating Free-Air Temperature, T_A		0		70	°C

- NOTES: 1. Ripple must not exceed 0.2 volts peak-to-peak in the operating frequency range.
2. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.
3. Parts with 400 kHz (min) to 600 kHz (max) oscillator frequency are available if requested.

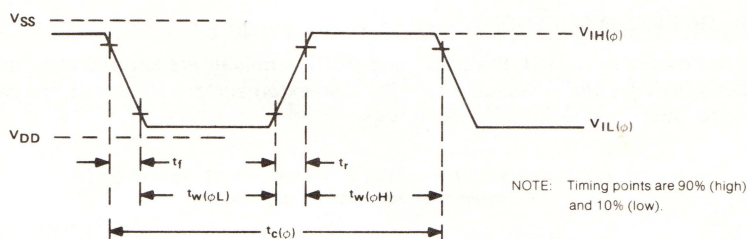


FIGURE 23 – EXTERNALLY DRIVEN CLOCK INPUT WAVEFORM

11.3 TMS 1000, 1100, 1200, 1300, 1700 (15 VOLT SERIES NLP) ELECTRICAL CHARACTERISTICS OVER RECOMMENDED OPERATING FREE-AIR TEMPERATURE RANGE (UNLESS OTHERWISE NOTED)

TMS 1000, 1100, 1200, 1300, 1700 (15 VOLT SERIES NLP)

PARAMETER		OPTIONS	TEST CONDITIONS	MIN	TYP*	MAX	UNIT
I_I	Input current	With pulldown	$V_I = 0\text{ V}$	50	300	500	μA
		No pulldown			0		
V_{OH}	High-level output voltage (see Note 1)	60 Ω standard	$I_O = -10\text{ mA}$	-1.1	-0.6		V
		130 Ω option		-2	-1.3		
I_{OL}	Low-level output current	No option	$V_{OL} = V_{DD}$	-0.75	-0.4		μA
						10	
I_{OSS}	Pulldown short circuit current	No pulldown	$V_O = V_{SS}, V_{DD} = -15\text{ V}$		0		μA
		100 μA pulldown		100			
		200 μA pulldown		200			
		300 μA pulldown		300			
		500 μA pulldown		500			
		900 μA pulldown		900			
		No pulldown			0		
		100 μA pulldown		100			
		150 μA pulldown		150			
		200 μA pulldown		200			
V_{OL}	Low-level output voltage	No pulldown	$I_O = 50\text{ }\mu\text{A}, V_{DD} = 15\text{ V}$	Not Applicable			V
		With pulldown		-11	-10		
I_{DD}	Average supply current from V_{DD} (see Note 2)	1000,1200,1700	All outputs open	-4.5	-10		mA
		1100,1300		-7	-11		
P_{AV}	Average power dissipation	1000,1200,1700	All outputs open	68	175		mW
		1100,1300		105	193		
f_{osc}	Internal oscillator frequency	1000,1100,1700	$R_{ext} = 33\text{ k}\Omega, C_{ext} = 100\text{ pF}$	250	300	350	kHz
		1200,1300	$R_{ext} = 36\text{ k}\Omega, C_{ext} = 100\text{ pF}$				
C_i	Small-signal input capacitance		$V_I = 0, f = 1\text{ kHz}$		10		pF
$C_{i(\phi)}$	Input capacitance, clock input		$V_I = 0, f = 100\text{ kHz}$		25		pF

* All typical values are at $V_{DD} = -15\text{ V}, T_A = 25^\circ\text{C}$.

NOTES 1. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.

2. I_{DD} max will be increased by the addition of pulldowns adding 2 times the minimum current spec per buffer.

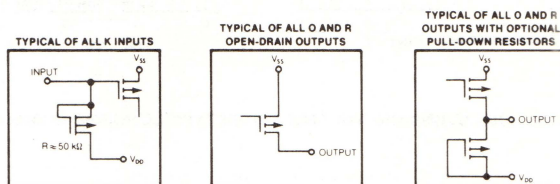


FIGURE 24 – TMS 1000, 1100, 1200, 1300, 1700 SCHEMATICS OF INPUTS AND OUTPUTS

11.4 INTERNAL OR EXTERNAL CLOCK

If the internal oscillator is used, the OSC1 and OSC2 terminals are shorted together and tied to an external resistor to V_{DD} and a capacitor to V_{SS} . If an external clock is desired, the clock source may be connected to OSC1 and OSC2 shorted to V_{SS} .

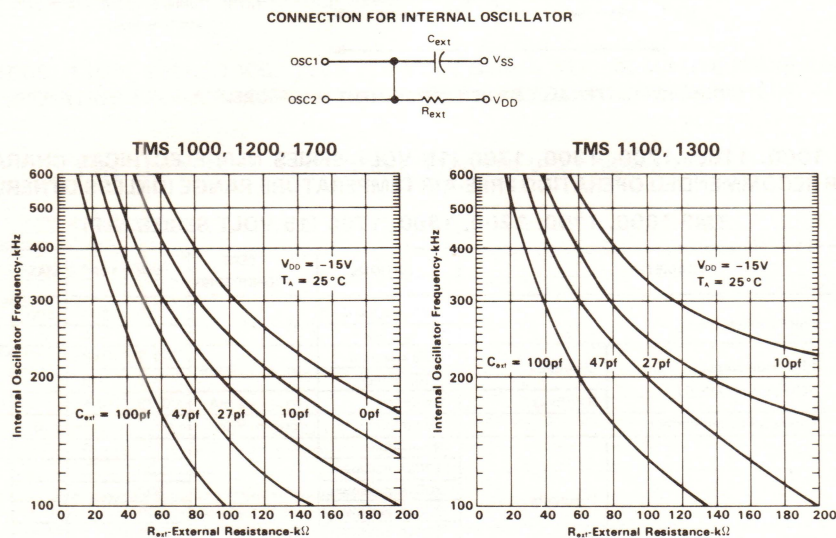


FIGURE 25 – TMS 1000 STANDARD VOLTAGE PMOS SERIES TYPICAL OSCILLATOR FREQUENCY VS. EXTERNAL RESISTANCE

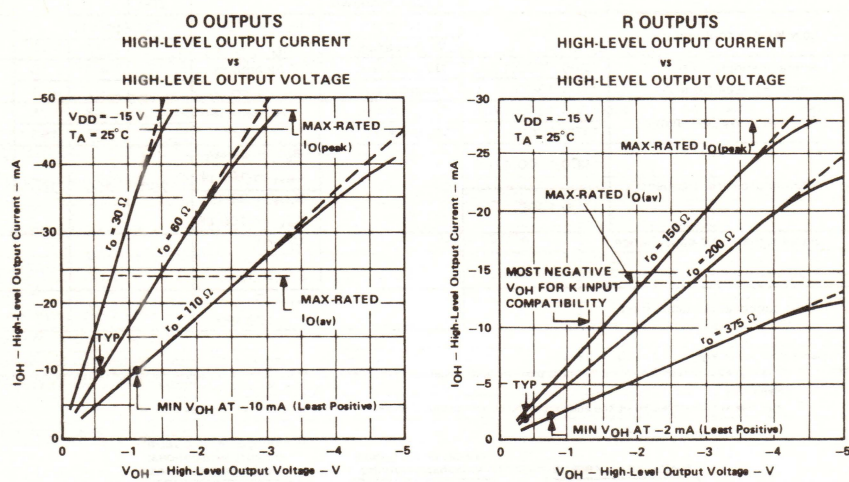


FIGURE 26 – TMS 1000 STANDARD VOLTAGE SERIES TYPICAL BUFFER CHARACTERISTICS

12. TMS 1070, 1170, 1270, 1370 (15 VOLT SERIES NLP) ELECTRICAL SPECIFICATIONS

12.1 TMS 1070, 1170, 1270, 1370 (15 VOLT SERIES NLP) ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE (UNLESS OTHERWISE NOTED)*

TMS 1070, 1170, 1270, 1370 (15 VOLT SERIES NLP)

Supply Voltage, V_{DD} (See Note 1)		- 20V to 0.3V
Data Input and Output Voltage with V_{DD} applied (See Note 2)		- 35V to 0.3V
Clock Input and INIT Voltage		- 20V to 0.3V
Average Output Current (See Note 3, 4)	O Outputs	- 2.5mA
	R Outputs	- 12mA
Peak Output Current (See Note 4)	O Outputs	- 5mA
	R Outputs	- 24mA
Continuous Power Dissipation	1070, 1170	400mW
	1270, 1370	600mW
Operating free-air temperature range		0°C to 70°C
Storage temperature range		- 55° to 150° C

* Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. Unless otherwise noted, all voltages are with respect to V_{SS} .
2. V_{DD} must be within the recommended operating conditions specified.
3. These average values apply for any 100 ms period.
4. Use of multiple outputs at the maximum ratings may violate the I_{SS} capability of the device. Contact Texas Instruments concerning applications of this type.

12.2 TMS 1070, 1170, 1270, 1370 (15 VOLT SERIES NLP) RECOMMENDED OPERATING CONDITIONS

TMS 1070, 1170, 1270, 1370 (15 VOLT SERIES NLP)

PARAMETER	MIN	NOM	MAX	UNIT
Supply Voltage, V_{DD} (See Note 1)	- 14	- 15	- 17.5	V
Applied Input and Output Voltage Range		-30	-35	V
High-Level Input Voltage, V_{IH} (See Note 2)	K	-6	0.3	V
	INIT or CLOCK	- 1.3	- 1	0.3
Low-Level Input Voltage, V_{IL} (See Note 2)	K	-33	- 12	V
	INIT or CLOCK	V_{DD}	- 15	- 8
Clock Cycle Time, $t_{c(\phi)}$	2.5	3	10	μ S
Instruction Cycle Time, t_c	15		60	μ S
Pulse Width, Clock High, $t_w(\phi H)$	1			μ S
Pulse Width, Clock Low, $t_w(\phi L)$	1			μ S
Sum of Rise Time and Pulse Width, Clock High, $t_r + t_w(\phi H)$	1.25			μ S
Sum of Fall Time and Pulse Width, Clock Low, $t_f + t_w(\phi L)$	1.25			μ S
Oscillator Frequency, f_{osc}	100		400	kHz
Operating Free-Air Temperature, T_A	0		70	°C

- NOTES: 1. Ripple must not exceed 0.2 volts peak-to-peak in the operating frequency range.
2. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.

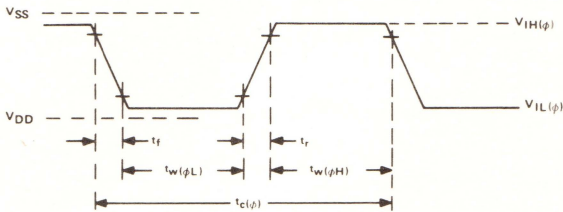


FIGURE 27 – EXTERNALLY DRIVEN CLOCK INPUT WAVEFORM

12.3 TMS 1070, 1170, 1270, 1370 (15 VOLT SERIES NLP) ELECTRICAL CHARACTERISTICS OVER RECOMMENDED OPERATING FREE-AIR TEMPERATURE RANGE (UNLESS OTHERWISE NOTED)

TMS 1070, 1170, 1270, 1370 (15 VOLT SERIES NLP)

PARAMETER		TEST CONDITIONS	MIN	TYP*	MAX	UNIT
I_I Input Current		$V_I = 0V$	40	100	300	μA
		No Pull-down		0		
V_{OH} High-Level Output Voltage (See Note 1)	O Outputs	$I_O = -1mA$	-1	-0.5		V
	R Outputs	$I_O = -10mA$	-4.5	-2.25		
I_{OL} Low-Level Output Current		$V_{OL} = -35V$			-50	μA
I_{DD} Average Supply Current from V_{DD}	1070, 1270	All Outputs Open		-6	-10	mA
	1170, 1370			-7	-13	
P_{AV} Average Power Dissipation	1070, 1270	All Outputs Open		90	175	mW
	1170, 1370			105	228	
f_{osc} Internal Oscillator Frequency		$R_{ext} = 33k\Omega$, $C_{ext} = 100pF$	250	300	350	kHz
C_i Small-Signal Input Capacitance, K Inputs		$V_I = 0$ $f = 1kHz$		10		pF
$C_i(\phi)$ Input Capacitance, Clock Input		$V_I = 0$ $f = 100kHz$		25		pF

* All typical values are at $V_{DD} = -15V$, $T_A = 25^\circ C$.

NOTES: 1. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.

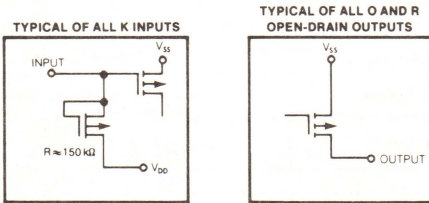


FIGURE 28 – TMS 1070, 1170, 1270, 1370 STANDARD VOLTAGE SERIES SCHEMATICS OF INPUTS AND OUTPUTS

12.4 INTERNAL OR EXTERNAL CLOCK

If the internal oscillator is used, the OSC1 and OSC2 terminals are shorted together and tied to an external resistor to V_{DD} and a capacitor to V_{SS} . If an external clock is desired, the clock source may be connected to OSC1 and OSC2 shorted to V_{SS} .

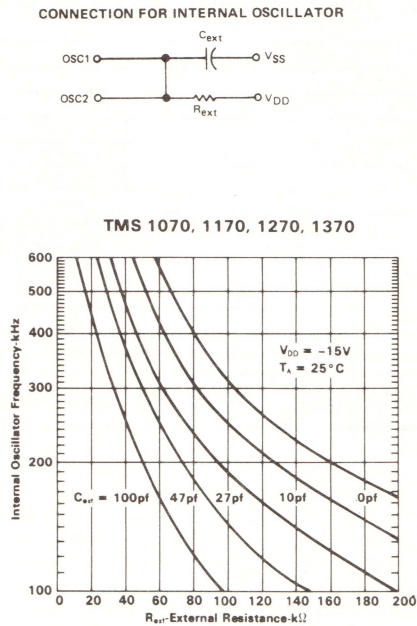


FIGURE 29 – TMS 1X70 STANDARD VOLTAGE PMOS SERIES TYPICAL OSCILLATOR
FREQUENCY VS. EXTERNAL RESISTANCE

13. TMS 1000, 1100, 1200, 1300, 1400, 1600, 1700 (9 VOLT SERIES NLL) ELECTRICAL SPECIFICATIONS

13.1 TMS 1000, 1100, 1200, 1300, 1400, 1600, 1700 (9 VOLT SERIES NLL) ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE (UNLESS OTHERWISE NOTED)*

TMS 1000, 1100, 1200, 1300, 1400, 1600, 1700 (9 VOLT SERIES NLL)

Supply Voltage, V_{DD} (See Note 1)		- 15V to 0.3V
Data Input and Output Voltage		- 15V to 0.3V
Clock Input and INIT Voltage		- 15V to 0.3V
Average Output current (See Note 2, 3)	O Outputs	- 24mA
	R Outputs	- 14mA
Peak Output Current (See Note 3)	O Outputs	- 48mA
	R Outputs	- 28mA
Continuous Power Dissipation	1000,1100,1400,1700	400mW
	1200,1300,1600	600mW
Operating free-air temperature range		0° C to 70° C
Storage temperature range		- 55° C to 150° C

* Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. Unless otherwise noted, all voltages are with respect to V_{SS} .
2. These average values apply for any 100 ms period.
3. Use of multiple outputs at the maximum ratings may violate the I_{SS} capability of the device. Contact Texas Instruments concerning applications of this type.

13.2 TMS 1000, 1100, 1200, 1300, 1400, 1600, 1700 (9 VOLT SERIES NLL) RECOMMENDED OPERATING CONDITIONS

TMS 1000, 1100, 1200, 1300, 1700 (9 VOLT SERIES NLL)

PARAMETER		MIN	NOM	MAX	UNIT
Supply Voltage, V_{DD} (See Note 1)		-7.5	-9.0	-10.0	V
High-Level Input Voltage, V_{IH} (See Note 2)	K	-1.0	-0.8	0.3	V
	INIT or CLOCK	-1.0	-0.8	0.3	
Low-Level Input Voltage, V_{IL} (See Note 2)	K	V_{DD}		-4.0	V
	INIT or CLOCK	V_{DD}	-9.0	-6.0	
Clock Cycle Time, $t_{C(\phi)}$		2.8	3	10	μ S
Instruction Cycle Time, t_c		17		60	μ S
Pulse Width, Clock High, $t_w(\phi H)$		1.2			μ S
Pulse Width, Clock Low, $t_w(\phi L)$		1.2			μ S
Sum of Rise Time and Pulse Width, Clock High, $t_r + t_w(\phi H)$		1.4			μ S
Sum of Fall Time and Pulse Width, Clock Low, $t_f + t_w(\phi L)$		1.4			μ S
Oscillator Frequency, f_{osc} (See Note 4)		100		350	kHz
Operating Free-Air Temperature, T_A		0		70	$^{\circ}$ C

TMS 1400, 1600 (9 VOLT SERIES NLL)

PARAMETER		MIN	NOM	MAX	UNIT
Supply Voltage, V_{DD} (See Note 1)		-7.5	-9	-10.0	V
High-Level Input Voltage, V_{IH} (See Note 2,3)	K,L,K/L,Mode	-1		0.3	V
	INIT or CLOCK	-1.0		0.3	
Low-Level Input Voltage, V_{IL} (See Note 2,3)	K,L,K/L,Mode	V_{DD}		-4	V
	INIT or CLOCK	V_{DD}		-6	
Clock Cycle Time, $t_{C(\phi)}$		1.82		3.3	μ S
Instruction Cycle Time, t_c		10.9		20	μ S
Pulse Width, Clock High, $t_w(\phi H)$		0.81			μ S
Pulse Width, Clock Low, $t_w(\phi L)$		0.81			μ S
Sum of Rise Time and Pulse Width, Clock High, $t_r + t_w(\phi H)$		0.91			μ S
Sum of Fall Time and Pulse Width, Clock Low, $t_f + t_w(\phi L)$		0.91			μ S
Oscillator Frequency, f_{osc} (See Note 5)		300		550	kHz
Operating Free-Air Temperature, T_A		0		70	$^{\circ}$ C

- NOTES: 1. Ripple must not exceed 0.2 volts peak-to-peak in the operating frequency range.
2. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.
3. L inputs for TMS 1600 only.
4. Parts with 400 kHz (min) to 600 kHz (max) oscillator frequency are available if requested.
5. Parts with 100 kHz minimum frequency are available if requested.

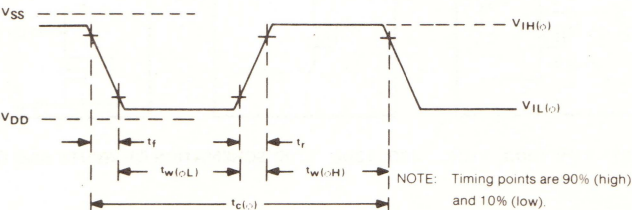


FIGURE 30 –EXTERNALLY DRIVEN CLOCK INPUT WAVEFORM

13.3 TMS 1000, 1100, 1200, 1300, 1400, 1600, 1700 (9 VOLT SERIES NLL) ELECTRICAL CHARACTERISTICS OVER RECOMMENDED FREE-AIR TEMPERATURE RANGE

TMS 1000, 1100, 1200, 1300, 1700 (9 VOLT SERIES NLL)

PARAMETER			OPTIONS	TEST CONDITIONS	MIN	TYP*	MAX	UNIT
I _I	Input current		With pulldown	V _I = 0 V	40	200	425	μA
			No pulldown			0		
V _{OH}	High level output voltage, (see Note 1)	O outputs	60Ω standard	I _O = -6 mA	-0.9	-0.4		V
			130Ω option		-1.3	-0.8		
		R outputs	No option	I _O = -1.2 mA	-0.75	-0.4		
I _{OL}	Low-level output current		No option	V _{OL} = V _{DD}			-10	μA
I _{OSS}	Pull-down short-circuit current	O outputs (see Note 2)	No pulldown	V _O = V _{SS} , V _{DD} = -9 V		0		μA
			50μA pulldown			50		
			125μA pulldown			125		
			225μA pulldown			225		
		R outputs (see Note 2)	No pulldown			0		
			50μA pulldown			50		
V _{OL}		Low-level output voltage	No pulldown	I _O = 50μA, V _{DD} = -9 V	Not Applicable			V
			With pulldown			-6	-5	
I _{DD}	Average supply current from V _{DD} (see Note 3)	1000,1200,1700	No pulldown	All outputs open		-4	-7	mA
		1100,1300	No pulldown			-5	-9	
P _{AV}	Average power dissipation	1000,1200,1700	No pulldown	All outputs open		36	70	mW
		1100,1300	No pulldown			45	90	
f _{osc}	Internal oscillator frequency	1000,1100,1700		R _{ext} = 44kΩ, C _{ext} = 100 pF	250	300	350	kHz
		1200,1300		R _{ext} = 30 kΩ, C _{ext} = 100 pF	250	300	350	
C _i	Small-signal input capacitance K inputs			V _I = 0, f = 1 kHz		10		pF
C _{i(φ)}	Input capacitance, clock input			V _I = 0, f = 100 kHz		25		pF

* All typical values are at V_{DD} = -9 V, T_A = 25 °C.

NOTES: 1. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.

2. One option can be chosen by the user for each output buffer.

3. I_{DD} max will be increased by the addition of pulldowns adding 2 times the minimum current spec per buffer.

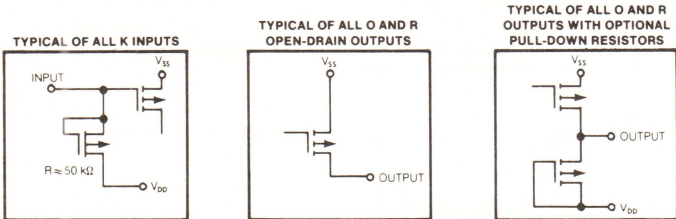


FIGURE 31 – TMS 1000, 1100, 1200, 1300, 1700 SCHEMATICS OF INPUTS AND OUTPUTS

TMS 1400, 1600 (9 VOLT SERIES NLL)

PARAMETER		OPTIONS	TEST CONDITIONS	MIN	TYP*	MAX	UNIT
I_I	Input current	With pulldown	$V_I = 0\text{ V}$	40	180	500	μA
V_{OH}	High-level output voltage (see Note 1)	O outputs	No option	$I_O = -6.0\text{ mA}$	0.9		V
		R outputs	No option	$I_O = -1.2\text{ mA}$	0.75		
I_{OL}	Low-level output current	No option	$V_{OL} = V_{DD}$			-100	μA
I_{OSS}	Pulldown short-circuit current (see Note 2)	O outputs	No pulldown		0		μA
			100 μA pulldown	100			
			300 μA pulldown	300			
			900 μA pulldown	900			
		R outputs	No pulldown		0		
			100 μA pulldown	100			
			300 μA pulldown	300			
V_{OL}	Low-level output voltage	No pulldown	$I_O = 50\mu\text{A}$	Not Applicable			V
		With pulldown	$V_{DD} = -9\text{ V}$		V_{DD}	-8	
I_{DD}	Average supply current from V_{DD} (see Note 3)	1400	No pulldown	All outputs open	-7	-15	mA
		1600	No pulldown	All outputs open	-7	-15	
P_{AV}	Average power dissipation	1400	No pulldown	All outputs open	63	150	mW
		1600	No pulldown	All outputs open	63	150	
f_{osc}	Internal oscillator frequency		$R_{ext} = 37\text{ k}\Omega$, $C_{ext} = 100\text{ pF}$	400	480	550	kHz
C_i	Small-signal input capacitance K inputs		$V_I = 0$, $f = 1\text{ kHz}$		10		pF
$C_{i(\phi)}$	Input capacitance, clock input		$V_I = 0$, $f = 100\text{ kHz}$		25		pF

* All typical values are at $V_{DD} = -9.0\text{ V}$, $T_A = 25^\circ\text{C}$.

- NOTES:
1. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.
 2. One option can be chosen by the user for each output pulldown.
 3. $I_{DD\text{ max}}$ will be increased by the addition of pulldowns adding 2 times the minimum current spec per buffer.

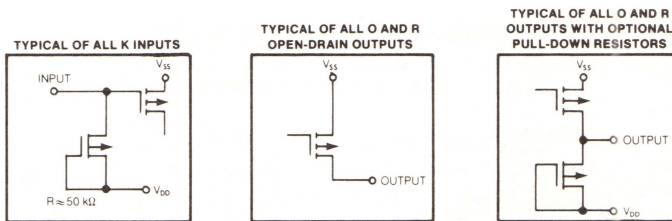


FIGURE 32 – TMS 1400, 1600 SCHEMATICS OF INPUTS AND OUTPUTS

13.4 INTERNAL OR EXTERNAL CLOCK

If the internal oscillator is used, the OSC1 and OSC2 terminals are shorted together and tied to an external resistor to V_{DD} and a capacitor to V_{SS} . If an external clock is desired, the clock source may be connected to OSC1 and OSC2 shorted to V_{SS} .

CONNECTION FOR INTERNAL OSCILLATOR

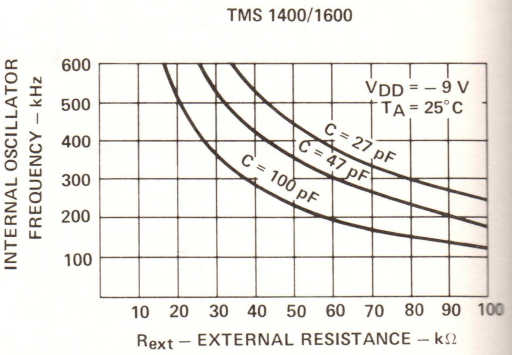
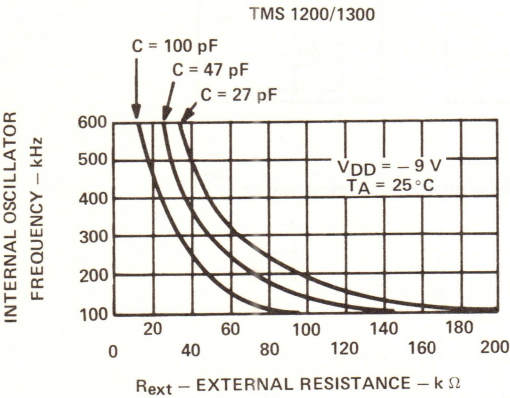
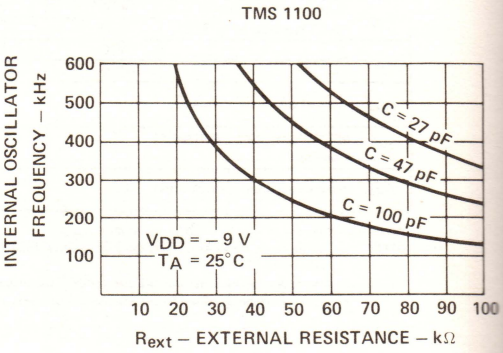
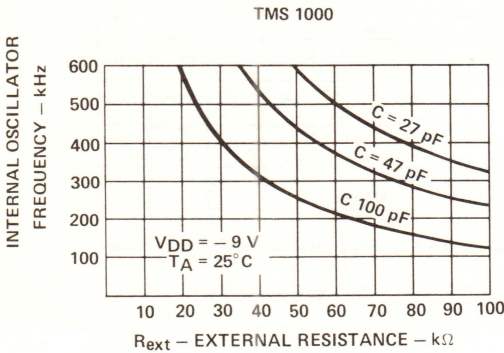
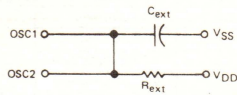


FIGURE 33 – TMS 1000 LOW VOLTAGE SERIES TYPICAL OSCILLATOR FREQUENCY VS. EXTERNAL RESISTANCE

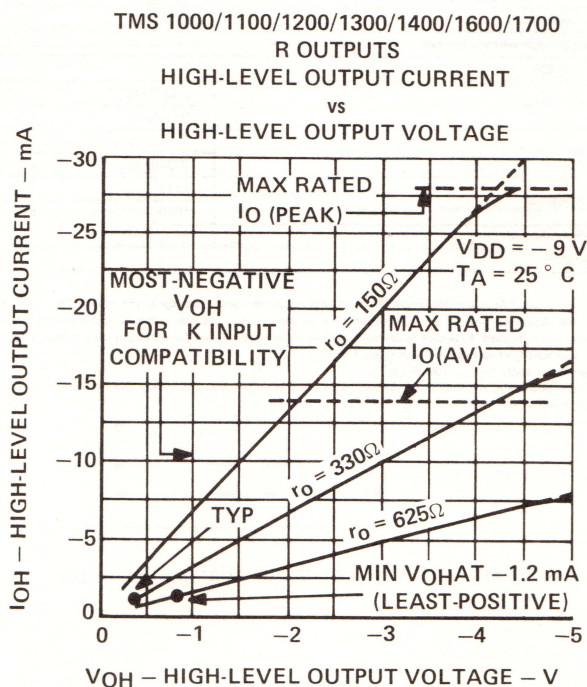
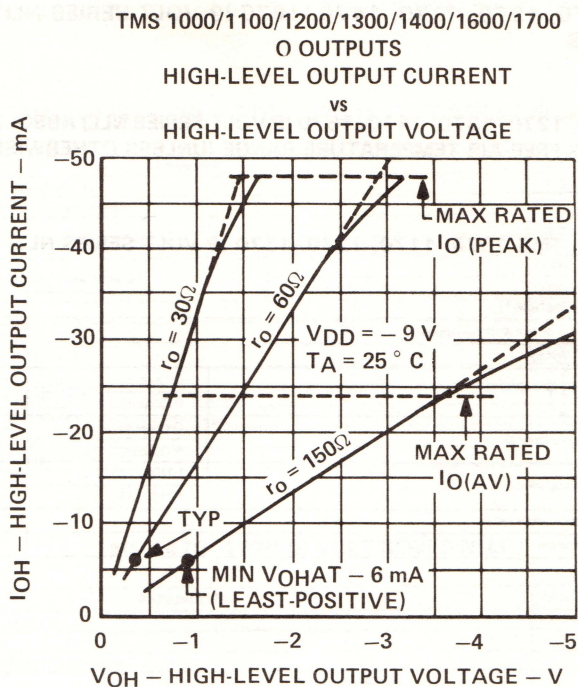


FIGURE 34 - TMS 1000 LOW VOLTAGE SERIES TYPICAL BUFFER CHARACTERISTICS

14. TMS 1070, 1170, 1270, 1370, 1470, 1670 (9 VOLT SERIES NLL) ELECTRICAL SPECIFICATIONS

14.1 TMS 1070, 1170, 1270, 1370, 1470, 1670 (9 VOLT SERIES NLL) ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE (UNLESS OTHERWISE NOTED)*

TMS 1070, 1170, 1270, 1370 (9 VOLT SERIES NLL)

Supply Voltage, V_{DD} (See Note 1)		- 15V to 0.3V
Data Input and Output Voltage with V_{DD} Applied		- 35V to 0.3V
Clock Input and INIT Voltage		- 15V to 0.3V
Average Output Current (See Note 2)	O Outputs	- 2.5mA
	R Outputs	- 12mA
Peak Output Current (See Note 3)	O Outputs	- 5mA
	R Outputs	- 24mA
Continuous Power Dissipation	1070, 1170,	400mW
	1270, 1370	600mW
Operating free-air temperature range		0 °C to 70 °C
Storage temperature range		- 55 °C to 150 °C

TMS 1470, 1670 (9 VOLT SERIES NLL)

Supply Voltage, V_{DD} (See Note 1)		- 15V to 0.3V
Data Input and Output Voltage with V_{DD} Applied		- 35V to 0.3V
Clock Input and INIT Voltage		- 15V to 0.3V
Average Output Current (See Note 2)	O Outputs	- 12mA
	R Outputs	- 12mA
Peak Output Current (See Note 3)	O Outputs	- 24mA
	R Outputs	- 24mA
Continuous Power Dissipation	1470	400mW
	1670	600mW
Operating free-air temperature range		0 °C to 70 °C
Storage temperature range		- 55 °C to 150 °C

* Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
1. Unless otherwise noted, all voltages are with respect to V_{SS} .
 2. These average values apply for any 100 ms period.
 3. Use of multiple outputs at the maximum ratings may violate the I_{SS} capability of the device. Contact Texas Instruments concerning applications of this type.

14.2 TMS 1070, 1170, 1270, 1370, 1470, 1670 (9 VOLT SERIES NLL) RECOMMENDED OPERATING CONDITIONS

TMS 1070, 1170, 1270, 1370 (9 VOLT SERIES NLL)

PARAMETER		MIN	NOM	MAX	UNIT
Supply voltage, V_{DD} (see Note 1)		-7.5	-9.0	-10.0	V
Applied input and output voltage range			-26	-30	V
High-level input voltage, V_{IH} (see Note 2)	K	-3.0	-1.5	0.3	V
	INIT or CLOCK	-0.8	-0.4	0.3	
Low-level input voltage, V_{IL} (see Note 2)	K	-30		-7.5	V
	INIT or CLOCK	V_{DD}	-9.0	-6.0	
Clock cycle time, $t_{C(\phi)}$		2.8	3	10	μ s
Instruction cycle time, t_C		17		60	μ s
Pulse width, clock high, $t_{W(\phi H)}$		1.2			μ s
Pulse width, clock low, $t_{W(\phi L)}$		1.2			μ s
Sum of rise time and pulse width, clock high, $t_r + t_{W(\phi H)}$		1.4			μ s
Sum of fall time and pulse width, clock low, $t_f + t_{W(\phi L)}$		1.4			μ s
Oscillator frequency, f_{OSC}		100		350	kHz
Operating free-air temperature, T_A		0		70	$^{\circ}$ C

TMS 1470, 1670 (9 VOLT SERIES NLL)

PARAMETER		MIN	NOM	MAX	UNIT
Supply voltage, V_{DD} (see Note 1)		-7.5	-9.0	-10.0	V
Supply voltage, V_{pp}			-26	-30	V
Applied input and output voltage range			-26	-30	V
High-level input voltage, V_{IH} (see Note 2)	K, L, K/L MODE	-2.4		0.3	V
	INIT or CLOCK	-1.0		0.3	
Low-level input voltage, V_{IL} (see Note 2)	K, L, K/L MODE	-30		-4	V
	INIT or CLOCK	V_{DD}		-4.5	
Clock cycle time, $t_{C(\phi)}$		1.82		3.3	μ s
Instruction cycle time, t_C		10.9		20	μ s
Pulse width, clock high, $t_{W(\phi H)}$		0.81			μ s
Pulse width, clock low, $t_{W(\phi L)}$		0.81			μ s
Sum of rise time and pulse width, clock high, $t_r + t_{W(\phi H)}$		0.91			μ s
Sum of fall time and pulse width, clock low, $t_f + t_{W(\phi L)}$		0.91			μ s
Oscillator frequency, f_{OSC} (see Note 3)		300		550	kHz
Operating free-air temperature, T_A		0		70	$^{\circ}$ C

- NOTES:
1. Ripple must not exceed 0.2 volts peak-to-peak in the operating frequency range.
 2. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.
 3. Parts with 100 kHz minimum frequency are available if requested.

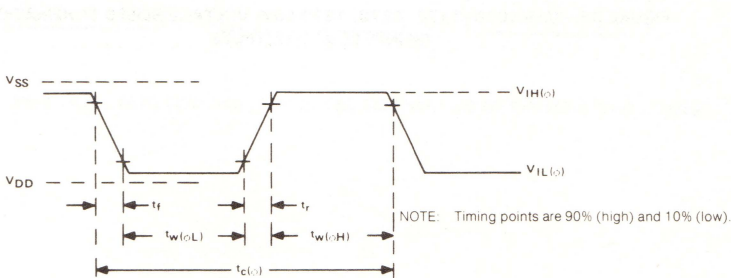


FIGURE 35 – EXTERNALLY DRIVEN CLOCK INPUT WAVEFORM

14.3 TMS 1070, 1170, 1270, 1370, 1470, 1670 (9 VOLT SERIES NLL) ELECTRICAL CHARACTERISTICS OVER RECOMMENDED OPERATING FREE-AIR TEMPERATURE RANGE (UNLESS OTHERWISE NOTED)*

TMS 1070, 1170, 1270, 1370 (9 VOLT SERIES NLL)

PARAMETER		TEST CONDITIONS	MIN	TYP*	MAX	UNIT
I_i Input Current		$V_i = 0V$	5		250	μA
V_{OH} High Level Output Voltage (See Note 1)	O Outputs	$I_O = -0.6mA$	-0.6	-0.2		V
	R Outputs	$I_O = -6mA$	-2.5	-1.4		
I_{OL} Low-Level Output Current		$V_{OL} = -30V$			-50	μA
I_{DD} Average Supply Current from V_{DD}		All Outputs Open		-5	-10	mA
P_{AV} Average Power Dissipation		All Outputs Open		45	100	mW
f_{OSC} Internal Oscillator Frequency		$R_{EXT} = 45k\Omega$ $C_{EXT} = 100pF$	250	300	350	kHz
C_i Small-signal Input Capacitance, K Inputs		$V_i = 0$ $f = 1kHz$		10		pF
$C(\phi)$ Input Capacitance, Clock Input		$V_i = 0$ $f = 100kHz$		25		pF

*All typical values are at $V_{DD} = -9V$, $T_A = 25^\circ C$
Notes: 1. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.

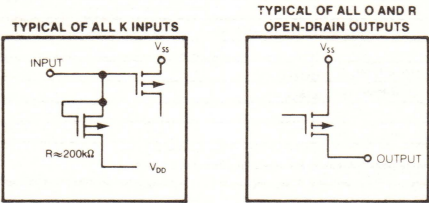


FIGURE 36 – TMS 1070, 1170, 1270, 1370 LOW VOLTAGE SERIES SCHEMATICS OF INPUTS AND OUTPUTS

TMS 1470, 1670 (9 VOLT SERIES NLL)

PARAMETER	OPTIONS	TEST CONDITIONS	MIN	TYP*	MAX	UNIT
I_I Input current	With pulldown	$V_I = 0\text{ V}$	40	180	400	μA
V_{OH} High-level output voltage (see Note 1)	O outputs	No option	$I_O = -5\text{ mA}$	-1.7	-1	V
	R outputs	No option	$I_O = -5\text{ mA}$	-1.7	-1	
I_{OL} Low-level output current	No option	$V_{OL} = -30\text{ V}$			-25	μA
I_{OSS} Pulldown short-circuit current (see Note 2)	O outputs	No pulldown		0		μA
		100 μA pulldown		100		
		300 μA pulldown		300		
		900 μA pulldown		900		
	R outputs	No pulldown		0		
		100 μA pulldown		100		
		300 μA pulldown		300		
V_{OL} Low-level output voltage	No pulldown	$I_O = 50\text{ }\mu\text{A}$, $V_{DD} = -9\text{ V}$, $V_{PP} = -30\text{ V}$	Not Applicable			V
	With pulldown			V_{PP}	-25	
I_{DD} Average supply current from V_{DD} (see Note 3)	1470	No pulldown	All outputs open	-8.5	-15	mA
	1670	No pulldown		-8.5	-15	
P_{AV} Average power dissipation	1470	No pulldown	All outputs open	77	150	mW
	1670	No pulldown		77	150	
f_{osc} Internal oscillator frequency		$R_{ext} = 37\text{ k}\Omega$, $C_{ext} = 100\text{ pF}$	400	480	550	kHz
C_I Small-signal input capacitance K inputs		$V_I = 0$, $f = 1\text{ kHz}$		10		pF
$C_{I(\phi)}$ Input capacitance, clock input		$V_I = 0$, $f = 100\text{ kHz}$		25		pF

* All typical values are at $V_{DD} = -9.0\text{ V}$, $T_A = 25^\circ\text{C}$.

- NOTES:
1. The algebraic convention where the most positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.
 2. One option can be chosen by the user for each output pulldown.
 3. $I_{DD\text{ max}}$ will be increased by the addition of pulldowns adding 2 times the minimum current spec per buffer.

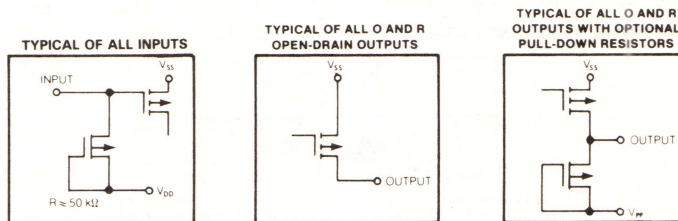


FIGURE 37 – TMS 1470, 1670 LOW VOLTAGE SERIES SCHEMATICS OF INPUTS AND OUTPUTS

14.4 INTERNAL OR EXTERNAL CLOCK

If the internal oscillator is used, the OSC1 and OSC2 terminals are shorted together and tied to an external resistor to V_{DD} and a capacitor to V_{SS} . If an external clock is desired, the clock source may be connected to OSC1 and OSC2 shorted to V_{SS} .

CONNECTION FOR INTERNAL OSCILLATOR

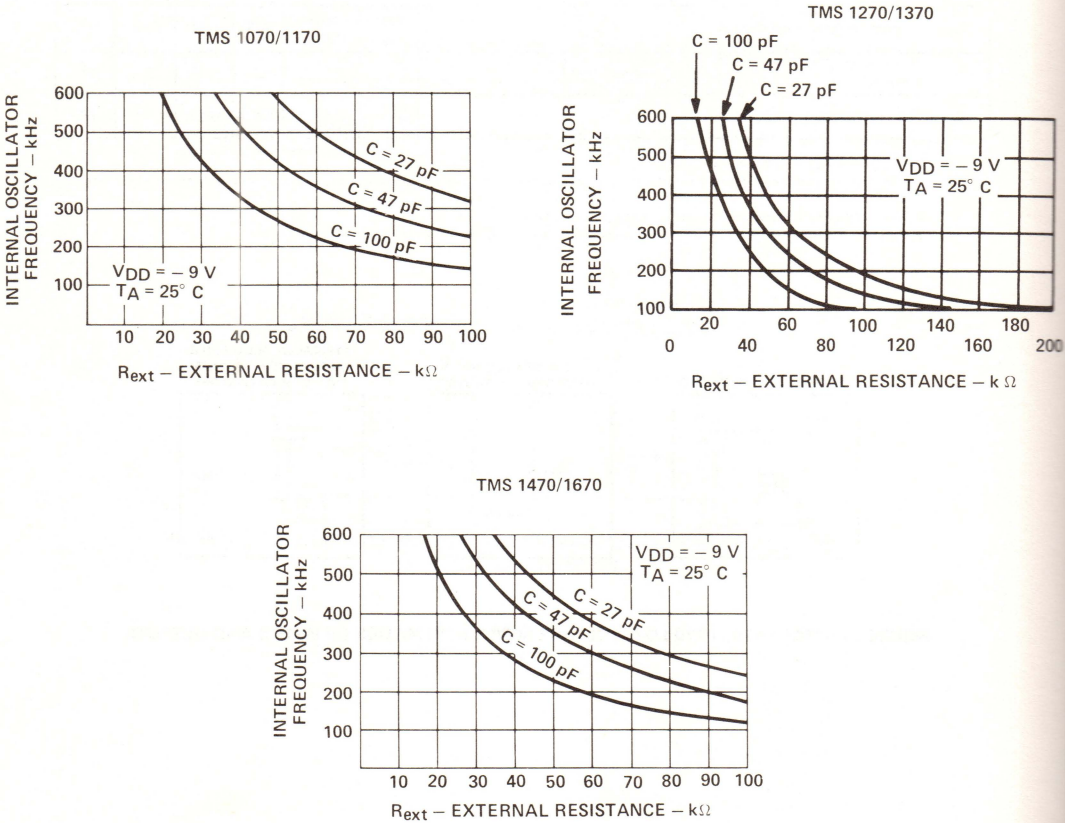
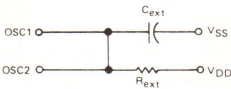


FIGURE 38 – TMS 1000 9 VOLT SERIES TYPICAL OSCILLATOR FREQUENCY VS. EXTERNAL RESISTANCE

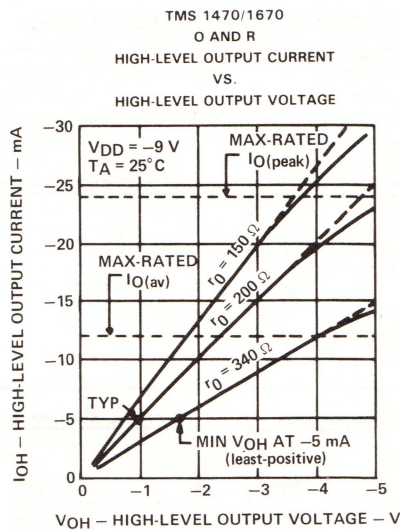
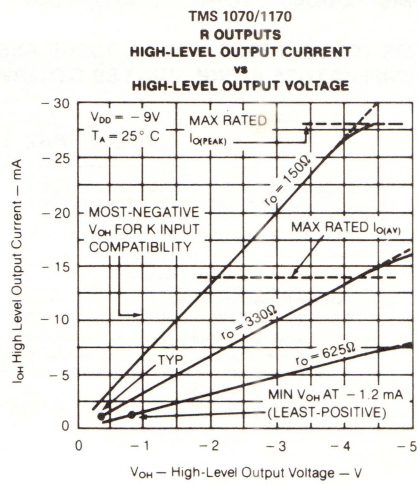
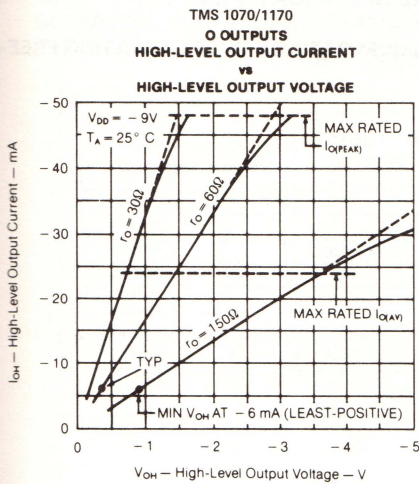


FIGURE 39 - TMS 1070, 1170, 1470, 1670 TYPICAL BUFFER CHARACTERISTICS

15. TMS 1000C, 1100C, 1200C, 1300C ELECTRICAL SPECIFICATIONS

15.1 TMS 1000C, 1100C, 1200C, 1300C ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE (UNLESS OTHERWISE NOTED)

TMS 1000C, 1100C, 1200C, 1300C

Supply voltage, V_{DD} (see Note 2)		- 0.3 to 10V
Voltage supplied to any device terminal (see Note 1)		- 0.3 to V_{DD}
Continuous power dissipation	1000C, 1100C	400 mW
	1200C, 1300C	600 mW
Operating free-air temperature range		- 0 C to 70 C
Storage temperature range		- 55 C to + 150 C

NOTES: 1. Stresses beyond those listed under "Absolute Maximum Rating" may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
2. Unless otherwise noted, all voltages are with respect to V_{SS} .

15.2 TMS 1000C, 1100C, 1200C, 1300C RECOMMENDED OPERATING CONDITIONS

TMS 1000C, 1100C, 1200C, 1300C

PARAMETER	MIN	MAX	UNIT
Supply voltage, V_{DD}	3	6	Volts
Input voltage, V_I	0	V_{DD}	Volts
Operating free-air temperature, T_A	0	70	C

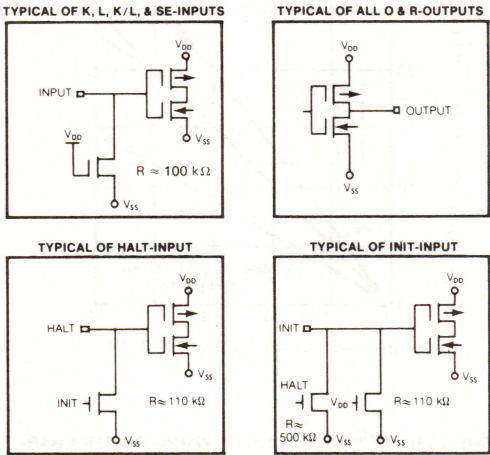


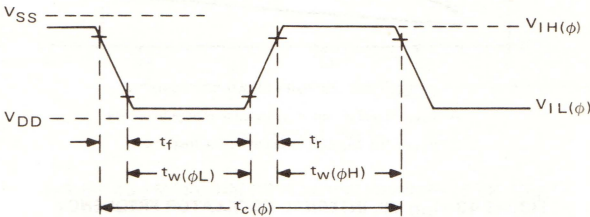
FIGURE 40 – TMS 1000 CMOS SERIES SCHEMATICS OF INPUTS AND OUTPUTS

15.3 TMS 1000C, 1100C, 1200C, 1300C ELECTRICAL CHARACTERISTICS OVER RECOMMENDED OPERATING FREE-AIR TEMPERATURE RANGE

TMS 1000C, 1100C, 1200C, 1300C

PARAMETER			TEST CONDITIONS	V _{DD} =3V			V _{DD} =5V			V _{DD} =6V			UNIT
				MIN	TYP*	MAX	MIN	TYP*	MAX	MIN	TYP*	MAX	
V _{IH}	High-level	Logic		1.9			3.1			3.8			V
	input voltage	INIT, OSC1		2.5			4.5			5.5			V
V _{IL}	Low-level	Logic				0.9			1.8			2.3	V
	input voltage	INIT, OSC1				0.5			0.5			0.5	V
V _{OH}	High-level output voltage	I _O = I _{OH} Min		1.9			3.1			3.8			V
V _{OL}	Low-level output voltage	I _O = I _{OL} Min				0.9			1.8			2.3	V
I _{OH}	Output source current	V _O = V _{OH} Min		-0.7			-2.3			-3.1			mA
I _{OL}	Output sink current	V _O = V _{OL} Max		1			2.9			4.7			mA
I _{IH}	High-level input current	V _I = V _{DD}			12	25		50	80		65	100	μA
I _{IL}	Low-level input current	V _I = 0V				-2			-2			-2	μA
I _{DD}	Average supply current	1000, 1200	R _{EXT} = 10kΩ, f _{OSC} = f _{max}			0.2	1.0	0.7	2	0.9	2.6	mA	
		1100, 1300	All outputs open			0.3	1.5	1.0	3	1.4	4		
I _{DD}	Quiescent supply current	1000, 1200	HLT = V _{DD}			0.1	10	0.1	10	0.1	10	μA	
		1100, 1300	All outputs open			0.2	20	0.2	20	0.2	20		
P _{AV}	Average power dissipation	1000, 1200	R _{EXT} = 10kΩ, f _{OSC} = f _{max}			0.6	3.0	3.5	10	5.4	10	mW	
		1100, 1300	All outputs open			0.9	4.5	5.0	15	8.4	24		
f _{OSC}	Clock frequency			.05		0.3	.05		1	.05		1	MHz
													kHz
								675	800	925		800	
t _{INST}	Instruction cycle time			20		120	6		120	6		120	μs
t _w (φH)	Pulse width clock high			1.3			0.4			0.4			μs
t _w (φL)	Pulse width, clock low			1.3			0.4			0.4			μs
t _r , t _f	Clock rise and fall time					1.0			1.0			1.0	μs
t _w (L)	Pulse width, L-latch			140	450			100	300		90	300	μs
C _i	Small-signal input capacitance	V _I = 0V, f _{OSC} = 1 kHz		10				10			10		pF
C _i (φ)	Clock input capacitance	V _I = 0V, f _{OSC} = 100 kHz		25				25			25		pF

*All TYP values are at T_A = 25°C.



NOTE: Timing points are 90% (high) and 10% (low).

FIGURE 41 – EXTERNALLY DRIVEN CLOCK INPUT WAVEFORM

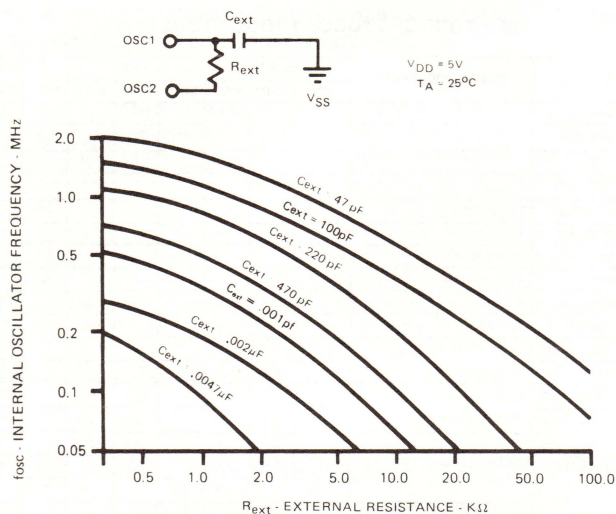


FIGURE 42 - INTERNAL OSCILLATOR FREQUENCY VS. EXTERNAL RESISTANCE

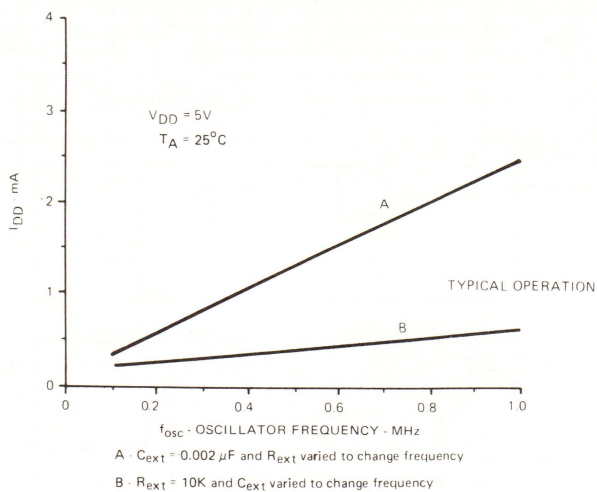


FIGURE 43 - I_{DD} VS. INTERNAL OSCILLATOR FREQUENCY

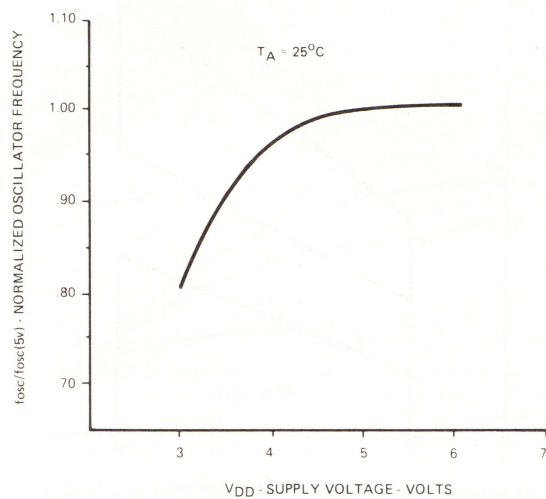


FIGURE 44 – NORMALIZED INTERNAL OSCILLATOR FREQUENCY VS. V_{DD}

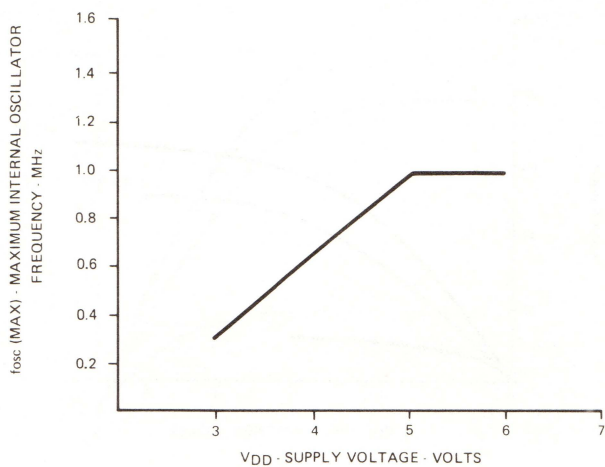


FIGURE 45 – MAXIMUM OSCILLATOR FREQUENCY VS. V_{DD}

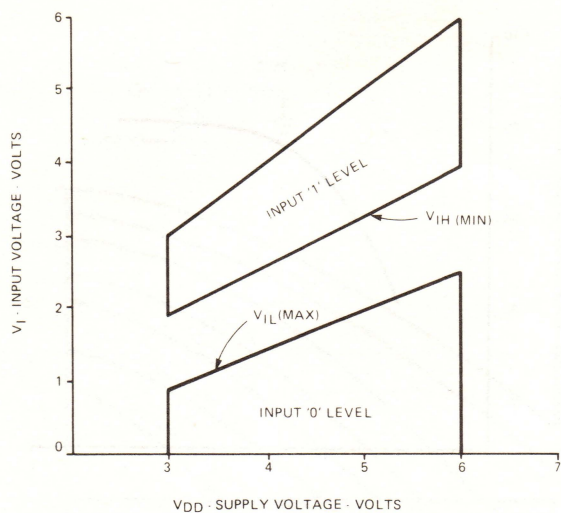


FIGURE 46 - INPUT LOGIC LEVELS VS. V_{DD}

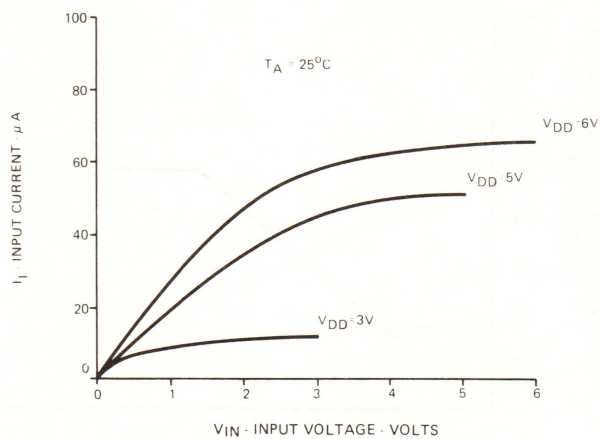


FIGURE 47 - TYPICAL INPUT CURRENT VS. INPUT VOLTAGE

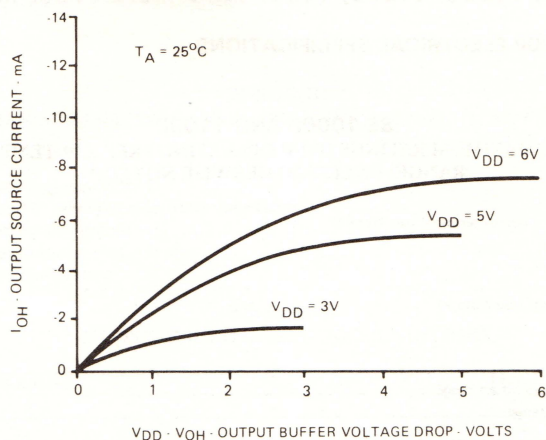


FIGURE 48 – TYPICAL OUTPUT SOURCE CHARACTERISTICS

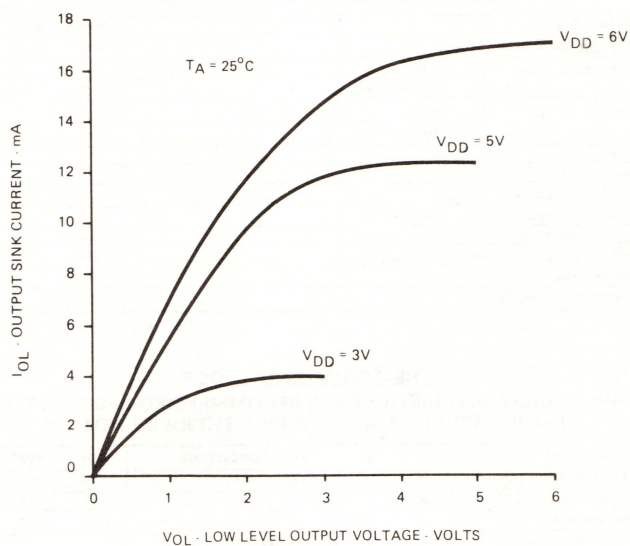


FIGURE 49 – TYPICAL OUTPUT SINK CHARACTERISTICS

16. SE-1000P, 1100P, 1000C, 1100C, 1400P ELECTRICAL SPECIFICATIONS

16.1 SE-1000P AND 1100P ELECTRICAL SPECIFICATIONS

SE-1000P AND 1100P

ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE
(RANGE) UNLESS OTHERWISE NOTED)*

Voltage applied to any device terminal (see Note 1)	−20 V
Supply voltage, V_{DD}	−20 V to 0.3 V
Data input voltage	−20 V to 0.3 V
Clock input voltage	−20 V to 0.3 V
Average output current (see Note 2)	
O, R, PC, PA, CA	−14 mA
Peak output current	
O, R, PC, PA, CA	−28 mA
Operating free-air temperature	0°C to 70°C
Storage temperature range	−55°C to 150°C

*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

SE-1000P AND 1100P

RECOMMENDED OPERATING CONDITIONS

PARAMETER		MIN	NOM	MAX	UNIT
Supply voltage, V_{DD} (see Note 3)		−14	−15	−17.5	V
High-level input voltage, V_{IH} (see Note 4)	K or I	−1.3	−1	0.3	V
	INIT or Clock	−1.3	−1	0.3	
Low-level input voltage, V_{IL} (see Note 4)	K or I	V_{DD}		−4	V
	INIT or Clock	V_{DD}	−15	−8	
Clock cycle time, $t_c(\phi)$		2.5	3	10	μ s
Instruction cycle time, t_c		15		60	μ s
Pulse width, clock high, $t_w(\phi H)$		1			μ s
Pulse width, clock low, $t_w(\phi L)$		1			μ s
Sum of rise time and pulse width, clock high, $t_r + t_w(\phi H)$		1.25			μ s
Sum of fall time and pulse width, clock low, $t_f + t_w(\phi L)$		1.25			μ s
Oscillator frequency, f_{osc}		100		400	kHz
Operating free-air temperature, T_A		0		70	°C

SE-1000P AND 1100P

ELECTRICAL CHARACTERISTICS OVER RECOMMENDED OPERATING FREE-AIR
TEMPERATURE RANGE (UNLESS OTHERWISE NOTED)

PARAMETER			TEST CONDITIONS		MIN	TYP†	MAX	UNIT	
I _I	Input current, K or I inputs		V _I = V _{SS}		50	300	500	μA	
V _{OH}	High-level output voltage (see Note 3)	O, PC, PA, and CA	I _O = −2 mA	−1	−0.5		V		
		R		−0.75	−0.4				
I _{OL}	Low-level output current			V _{OL} = V _{DD}			−100	μA	
I _{DD(av)}	Average supply current from V _{DD}			All outputs open		−7	−11	mA	
P(AV)	Average power dissipation			All outputs open			105	193	mW
f _{osc}	Internal oscillator frequency			R _{ext} = 50 kΩ, C _{ext} = 47 pF		250	300	350	kHz
C _i	Input capacitance, K or I inputs			V _I = 0 V, f = 1 kHz			10		pF
C _{i(φ)}	Input capacitance, clock inputs			V _I = 0 V, f = 100 kHz			25		pF

†Typical values are at $T_A = 25^\circ\text{C}$

- NOTES: 1. Throughout this data sheet supply voltage values are with respect to V_{SS} , unless otherwise noted.
2. Average current is specified over any 100-ms period.
3. Ripple must not exceed 0.2 volts peak-to-peak in the operating frequency range.
4. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.

16.2 SE-1000C ELECTRICAL SPECIFICATIONS

SE-1000C

ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE
(SEE NOTE 1)

Supply voltage, V_{DD} (see Note 2)	-0.3 to 10 V
Voltage supplied to any device terminal (see Note 1)	-0.3 to V_{DD}
Continuous power dissipation	400 mW
Operating free-air temperature range	0 to 70 °C
Storage temperature range	-55 to +150 °C

SE-1000C

RECOMMENDED OPERATING CONDITIONS

PARAMETER	MIN	MAX	UNIT
Supply voltage, V_{DD}	3.0	6.0	Volts
Input voltage, V_I	0	V_{DD}	Volts
Operating free-air temperature, T_A	0	70	°C

- NOTES: 1. Stresses beyond those listed under "Absolute Maximum Rating" may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
2. Unless otherwise noted, all voltages are with respect to V_{SS} .

SE-1000C

ELECTRICAL CHARACTERISTICS OVER RECOMMENDED OPERATING
FREE-AIR TEMPERATURE RANGE (0 to 70° C)

PARAMETER			TEST CONDITIONS		VDD = 3 V		VDD = 5 V		VDD = 6 V		UNIT
					MIN	TYP*MAX	MIN	TYP*MAX	MIN	TYP*MAX	
VIH	High level input voltage	Logic			1.9		3.1		3.8		V
		INIT, OSC1			2.5		4.5		5.5		V
VIL	Low level input voltage	Logic				0.9		1.8		2.3	V
		INIT, OSC1				0.5		0.5		0.5	V
VOH	High level output voltage	IO = IOH Min			1.9		3.1		3.8		V
VOL	Low level output voltage	IO = IOL Min				0.9		1.8		2.3	V
IOH	Output source current	VO = VOH Min			-0.7		-2.3		-3.1		mA
IOL	Output sink current	VO = VOL Max			1.0		2.9		4.7		mA
IiH	Input current	VIN = VDD	12	25			50	80	65	100	μA
IiL	Input leakage	VIN = 0 V		2.0			-2.0		-2.0		μA
IDD	Average supply current	Rext = 10K Ω; fosc = fmax All outputs open	0.2	1.0			0.7	2.0	0.9	2.6	mA
IDQ	Quiescent supply current	RLT = VDD All outputs open	0.1	10			0.1	10	0.1	10	μA
PAV	Average power dissipation	Rext = 10K Ω; fosc = fmax All outputs open	0.6	3.0			3.5	10	5.4	16	mW
Fosc	Clock frequency		.05	0.3		.05	1.0		.05	1.0	MHz
		Rext = 10K Ω; Cext = 560pF	250								KHz
		Rext = 10K Ω; Cext = 100pF				675	800	925	800		KHz
tiHst	Instruction cycle time		20	120		6	120		6	120	μsec
tw(OH)	Pulse width, clock high		1.3			0.4			0.4		μsec
tw(OL)	Pulse width, clock low		1.3			0.4			0.4		μsec
tr/tf	Clock rise and fall time		1.0			1.0			1.0		μsec
tw(L)	Pulse width, L-latch		140	450		100	300		90	300	μsec
Ci	Small signal input capacitance	VIN = 0 V, fosc = 1 KHz	10			10			10		pF
Ci(O)	Clock input capacitance	VIN = 0 V, fosc = 100 KHz	25			25			25		pF

*ALL TYP VALUES ARE AT $T_A = 25^\circ\text{C}$

16.3 SE-1100C ELECTRICAL SPECIFICATIONS

SE-1100C

ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE
(SEE NOTE 1)

Supply voltage, V_{DD} (see Note 2)	-0.3 to 10 V
Voltage supplied to any device terminal (see Note 1)	-0.3 to V_{DD}
Continuous power dissipation	600 mW
Operating free-air temperature range	0°C to 70°C
Storage temperature range	-55°C to +150°C

SE-1100C

RECOMMENDED OPERATING CONDITIONS

PARAMETER	MIN	MAX	UNIT
Supply voltage, V_{DD}	3	6	Volts
Input voltage, V_I	0	V_{DD}	Volts
Operating free-air temperature, T_A	0	70	°C

NOTES: 1. Stresses beyond those listed under "Absolute Maximum Rating" may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

2. Unless otherwise noted, all voltages are with respect to V_{SS} .

SE-1100C

ELECTRICAL CHARACTERISTICS OVER RECOMMENDED OPERATING
FREE-AIR TEMPERATURE RANGE (0 to 70°C)
(UNLESS OTHERWISE NOTED)

PARAMETER			TEST CONDITIONS			$V_{DD} = 3\text{ V}$			$V_{DD} = 5\text{ V}$			$V_{DD} = 6\text{ V}$			UNIT
						MIN	TYP*	MAX	MIN	TYP*	MAX	MIN	TYP*	MAX	
V_{IH}	High-level input voltage	Logic				1.9			3.1			3.8			V
		INIT, OSC1				2.5			4.5			5.5			V
V_{IL}	Low-level input voltage	Logic						0.9			1.8			2.3	V
		INIT, OSC1						0.5			0.5			0.5	V
V_{OH}	High-level output voltage	$I_O = I_{OH}\text{ Min}$				1.9			3.1			3.8			V
V_{OL}	Low-level output voltage	$I_O = I_{OL}\text{ Min}$						0.9			1.8			2.3	V
I_{OH}	Output source current	$V_O = V_{OH}\text{ Min}$				-0.7			-2.3			-3.1			mA
I_{OL}	Output sink current	$V_O = V_{OL}\text{ Max}$				1			2.9			4.7			mA
I_{IH}	High-level input current	$V_I = V_{DD}$					12	25		50	80		65	100	μA
I_{IL}	Low-level input current	$V_I = 0\text{ V}$						-2			-2			-2	μA
I_{DD}	Average supply current	$R_{ext} = 10\text{ k}\Omega$, $f_{osc} = f_{max}$ All outputs open				0.3	1.5		1.0	3		1.4	4		mA
I_{DQ}	Quiescent supply current	HLT = V_{DD} All outputs open				1.0			1.0			1.0			μA
P_{AV}	Average power dissipation	$R_{ext} = 10\text{ k}\Omega$, $f_{osc} = f_{max}$ All outputs open				0.9	4.5		5.0	15		8.4	24		mW
F_{osc}	Clock frequency					.05	0.3		.05	1		.05	1		MHz
		$R_{ext} = 10\text{ k}\Omega$, $C_{ext} = 560\text{ pF}$				250			675	800	925	800			kHz
		$R_{ext} = 10\text{ k}\Omega$, $C_{ext} = 100\text{ pF}$													kHz
t_{inst}	Instruction cycle time					20	120		6	120		6	120		μs
$t_{w(\phi H)}$	Pulse width, clock high					1.3			0.4			0.4			μs
$t_{w(\phi L)}$	Pulse width, clock low					1.3			0.4			0.4			μs
t_r, t_f	Clock rise and fall time						1.0			1.0			1.0		μs
$t_{w(L)}$	Pulse width, L-latch					140	450		100	300		90	300		μs
C_i	Small-signal input capacitance	$V_I = 0\text{ V}$, $f_{osc} = 1\text{ kHz}$				10			10			10			pF
$C_i(\phi)$	Clock input capacitance	$V_I = 0\text{ V}$, $f_{osc} = 100\text{ kHz}$				25			25			25			pF

* All TYP values are at $T_A = 25^\circ\text{C}$.

16.4 SE-1400P ELECTRICAL SPECIFICATIONS

SE-1400P

ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE
(UNLESS OTHERWISE NOTED)*

Voltage applied to any device terminal (see Note 1)	-15 V
Supply voltage, V _{DD}	-15 V to 0.3 V
Data input voltage	-15 V to 0.3 V
Clock input voltage	-15 V to 0.3 V
Average output current (see Note 2): O-Outputs	-24 mA
R-Outputs	-14 mA
Peak output current: O-Outputs	-48 mA
R-Outputs	-28 mA
Continuous power dissipation	600 mW
Operating free-air temperature range	0°C to 70°C
Storage temperature range	-55°C to 150°C

* Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

SE-1400P

RECOMMENDED OPERATING CONDITIONS

PARAMETER		MIN	NOM	MAX	UNIT
Supply voltage, V _{DD} (see Note 3)		-7.5	-9	-10.5	V
High-level input voltage, V _{IH} (see Note 4)	K/L	-2.4		0.3	V
	INIT or Clock	-1		0.3	
Low-level input voltage, V _{IL} (see Note 4)	K/L	V _{DD}		-4	V
	INIT or Clock	V _{DD}		-5	
Clock cycle time, t _{c(φ)}		1.82		3.3	μS
Instruction cycle timer, t _c		10.9		20	μS
Pulse width, clock high, t _{w(φH)}		0.81			μS
Pulse width, clock low, t _{w(φL)}		0.81			μS
Sum of rise time and pulse width, clock high, t _r + t _{w(φH)}		0.91			μS
Sum of fall time and pulse width, clock low, t _f + t _{w(φL)}		0.91			μS
Oscillator frequency, f _{osc}		300		550	kHz
Operating free-air temperature, T _A		0		70	°C

- NOTES
1. Unless otherwise noted, all voltages are with respect to V_{SS}.
 2. These average values apply for any 100 ms period.
 3. Ripple must not exceed 0.2 volts peak to peak in the operating frequency range.
 4. The algebraic convention where the more negative (less positive) limit is designated as minimum is used in this specification for logic voltage levels only.

SE-1400P

ELECTRICAL CHARACTERISTICS OVER RECOMMENDED OPERATING FREE-AIR TEMPERATURE RANGE (UNLESS OTHERWISE NOTED)

PARAMETER		TEST CONDITIONS	MIN	NOM [†]	MAX	UNIT
I _I	Input current, K inputs	V _I = 0 V	70	180	400	μA
V _{OH}	High-level output voltage (see Note 4)	O-Outputs I _O = -5 mA	-1.7			V
		R-Outputs I _O = -5 mA	-1.7			
I _{OL}	Low-level output current	V _{OL} = V _{DD}			-10	μA
I _{DD(AV)}	Average supply current from V _{DD} (see Note 5)	All outputs open		-7	-13	mA
P(AV)	Average power dissipation (see Note 5)	All outputs open		63	137	mW
f _{osc}	Internal oscillator frequency	R _{ext} = 47 kΩ, C _{ext} = 47 pF	450	500	550	kHz
C _i	Small-signal input capacitance, K inputs	V _I = 0, f = 1 kHz		10		pF
C _{i(φ)}	Input capacitance, clock input	V _I = 0, f = 100 kHz		25		pF

- [†] All typical values are at V_{DD} = -9 V, T_A = 25°C (low power version).
- NOTES:
4. The algebraic convention where the more negative (less-positive) limit is designated as minimum is used in this specification for logic voltage levels only.
 5. Values are given for the open-drain O and R output configurations. Pull-down devices are optionally available on all outputs and increase I_{DD}.

17. PIN ASSIGNMENT DIAGRAMS

17.1 TMS 1000, 1070, 1100, 1200, 1270, 1300, 1370, 1400, 1400A, 1470, 1600, 1670, 1700
PIN ASSIGNMENT DIAGRAMS

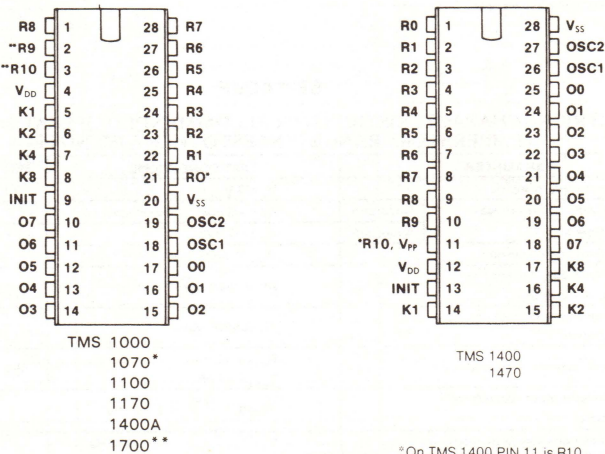
TABLE 11 – PIN DESCRIPTION

PIN	FUNCTION
R0 thru R15	R individually latched outputs
O0 - O9	O parallel data outputs
K1, 2, 4, 8	Data inputs
L1, 2, 4, 8	Latched data inputs
VDD	Power supply input
VSS	Ground pin
INIT	Power-on initialization and reset
OSC1*	Oscillator input if driven by external clock
OSC2	Oscillator output
K/L	Control signal for multiplexing K and L inputs (see Note 1)
Vpp	Vacuum-tube fluorescent display pulldown resistor supply
NC	No connection

* If external clock is used, OSC2 is tied to VSS.
NOTE 1. Active low selects K inputs. Active high selects L inputs.

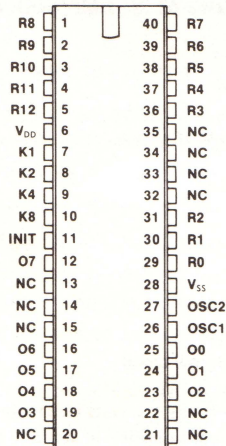
PIN ASSIGNMENT DIAGRAMS

The TMS 1000 series of microcomputers are pin-for-pin interchangeable as shown on the following pin assignment diagrams.

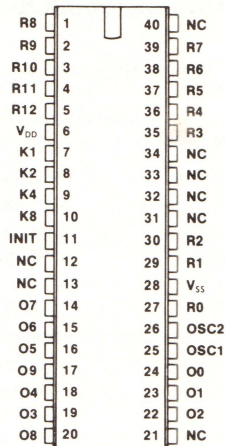


* On TMS 1070 PIN 21 is VSS
and PIN 20 is RO
** On TMS 1700 PINS 2 and 3
are NC
NC-No Connection

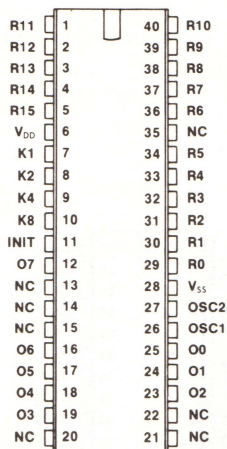
* On TMS 1400 PIN 11 is R10,
on TMS 1470 PIN 11 is Vpp



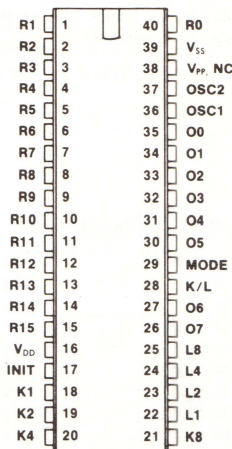
TMS 1200



TMS 1270



TMS 1300
1370



TMS 1600
1670

*On TMS 1600, PIN 38 is NC,
on TMS 1670, PIN 38 is V_{PP}

17.2 TMS 1000C, 1070C, 1100C, 1200C, 1270C, 1300C, PIN ASSIGNMENT DIAGRAMS

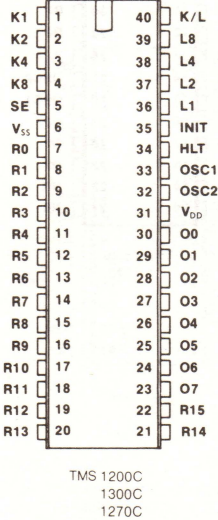
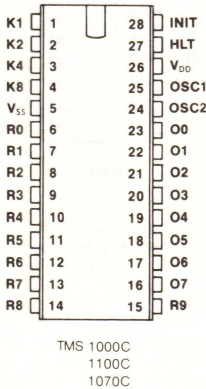
TABLE 12 – PIN DESCRIPTION

PIN	FUNCTION
R0 thru R15	R individually latched outputs
O0 thru O7	O parallel data outputs
K1, 2, 4, 8	Data Inputs
L1, 2, 4, 8	Data Inputs
VDD	Power supply input
VSS	Ground pin
INIT	Power-on initialization
OSC1	Oscillator input if driven by external clock
OSC2*	Oscillator output
K/L	Control signal for multiplexing K and L inputs (see Note 1)
HLT	Control pin for reduced power consumption in standby state (see Note 2)
SE	Control signal for selecting pass or sense mode for L port
NC	No connection

* If external clock is used, OSC2 is tied to VSS.

NOTES: 1. Active low selects K inputs. Active high selects L inputs.
2. Tied to VSS when not used.

PIN ASSIGNMENT DIAGRAMS



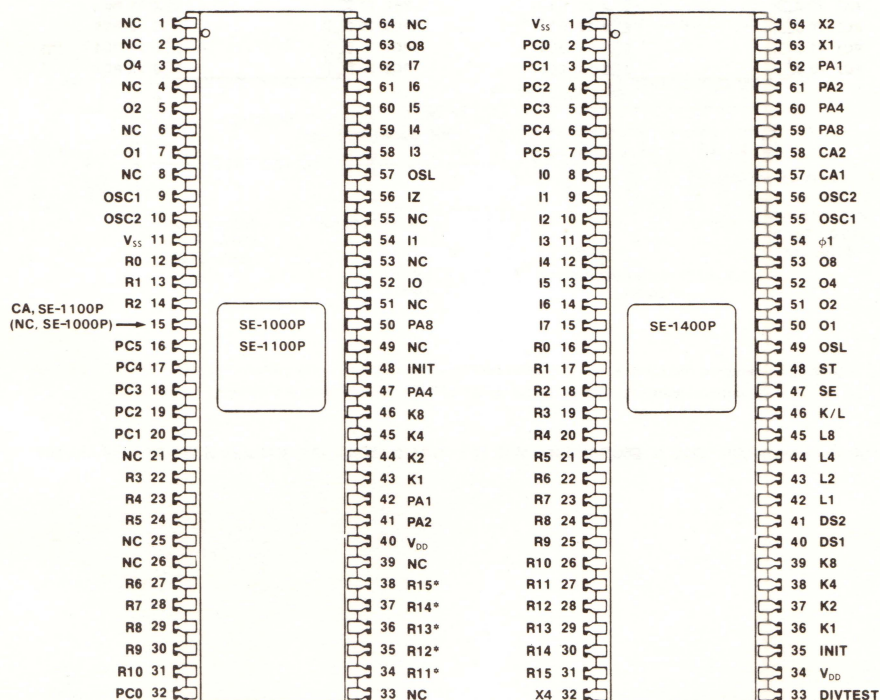
17.3 SE-1000P, 1100P, 1400P, 1000C, 1100C PIN ASSIGNMENT DIAGRAMS

TABLE 13 – SE-1000P AND SE-1100P TERMINAL FUNCTION DESCRIPTION

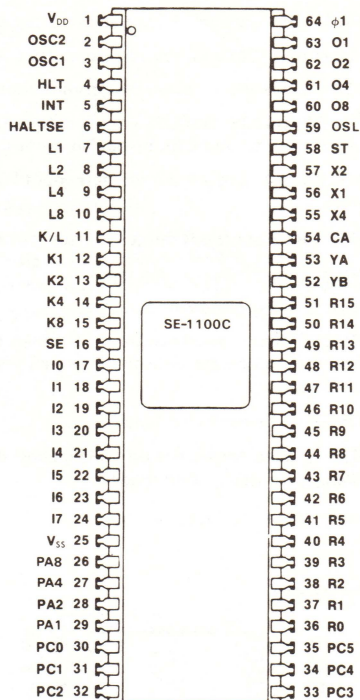
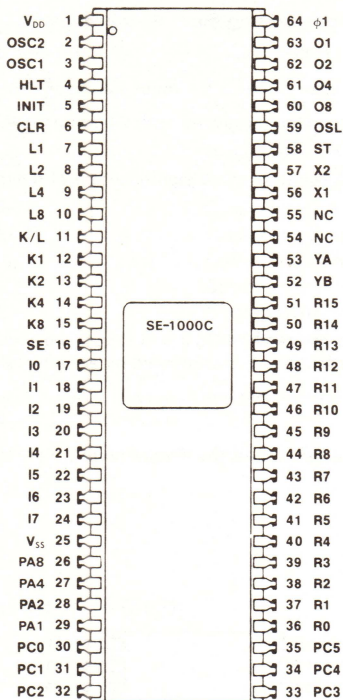
1. PC0 → PC5 are the ROM program-counter outputs with PC0 being the most-significant bit and PC5 being the least-significant bit. The addresses change in a non-sequential binary manner.
2. PA8 → PA1 are the ROM page-address outputs with PA8 being the most-significant bit.
3. CA is the ROM chapter address output for the SE-1100P.
4. I0 → I7 are the external-memory-instruction inputs with I0 being the most-significant bit.
5. O1, O2, O4, O8, and OSL are the data outputs latched in the O register, with O1 being the least-significant bit and OSL being the output of the status latch.
6. K1, K2, K4, and K8 are the data input lines with K1 being the least-significant bit of these inputs.
7. R0 → R15 are the R-output register outputs.
8. VDD is the power-supply input.
9. VSS is the ground pin.
10. OSC1[†] is the oscillator input if driven by an external clock. OSC1 and OSC2 are shorted together to operate with the internal oscillator. The frequency is controlled by an external RC circuit.
11. OSC2 is the oscillator output.
12. INIT is used for power-on initialization or hardware reset (see the *Programmer's Reference Manual* for more information).

[†] If an external clock is used, OSC2 is tied to V_{SS}.

PIN ASSIGNMENTS

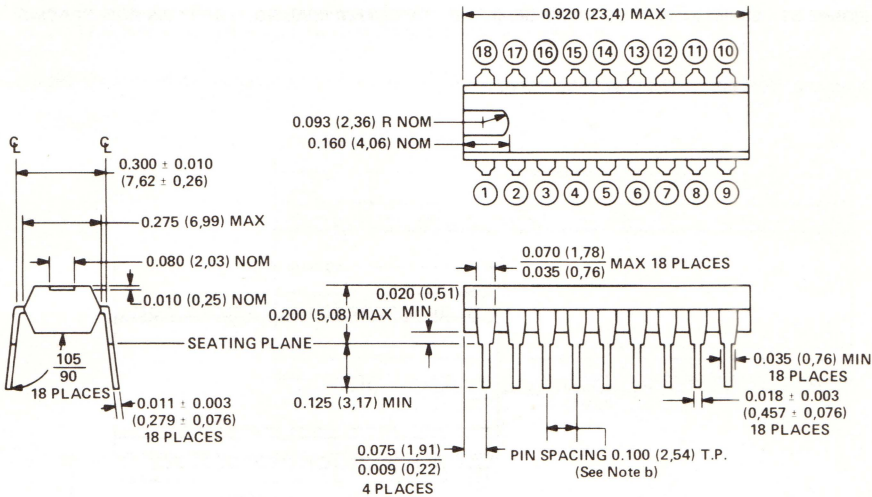


NC-No internal connection



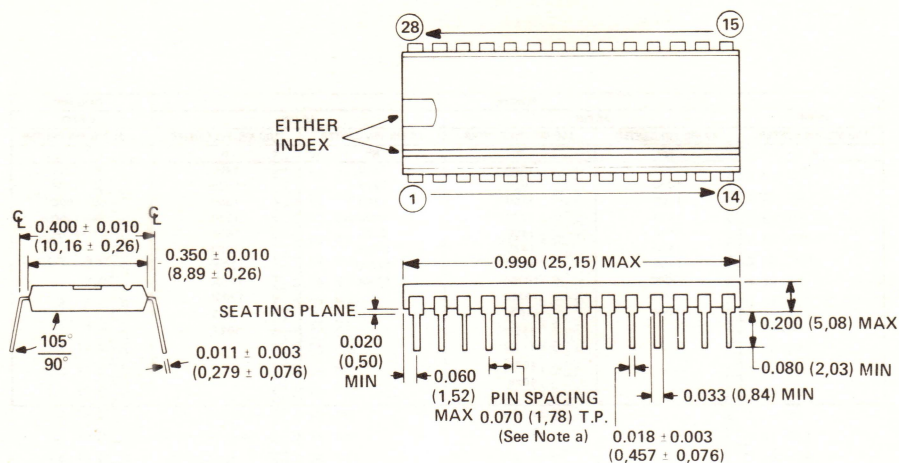
18. MECHANICAL DATA

PLASTIC						CERAMIC
18-PIN	28-PIN		40-PIN		64-PIN	
100 MIL PIN CENTER	70 MIL PIN CENTER	100 MIL PIN CENTER	70 MIL PIN CENTER	100 MIL PIN CENTER	100 MIL PIN CENTER	100 MIL PIN CENTER
N	NF	N	NF	N	J	
1976	1000	1000	1200	1200	SE-1000P	
	1070	1070	1270	1270	SE-1100P	
	1100	1100	1300	1300	SE-1000C	
	1170	1170	1600	1370	SE-1100C	
	1400	1400	1670	1600	SE-1400P	
	1470	1470	1200C	1670		
	1700	1700	1270C	1200C		
	1000C	1000C	1270C	1270C		
	1070C	1070C	1300C	1300C		
	1100C	1100C		1025		
		1121		1027		
		1117				
		1024				
		1026				



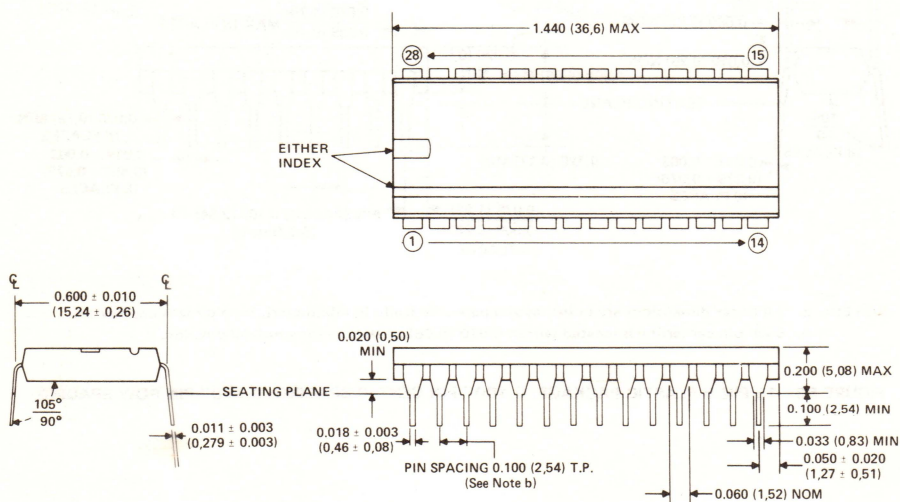
NOTES: a. All linear dimensions are in inches and parenthetically in millimeters. Inch dimensions govern.
b. Each pin centerline is located within 0.010 (0,26) of its true longitudinal position.

FIGURE 50 – 18-PIN N PLASTIC PACKAGE, 0.100" PIN CENTER SPACING, 0.300" PIN ROW SPACING



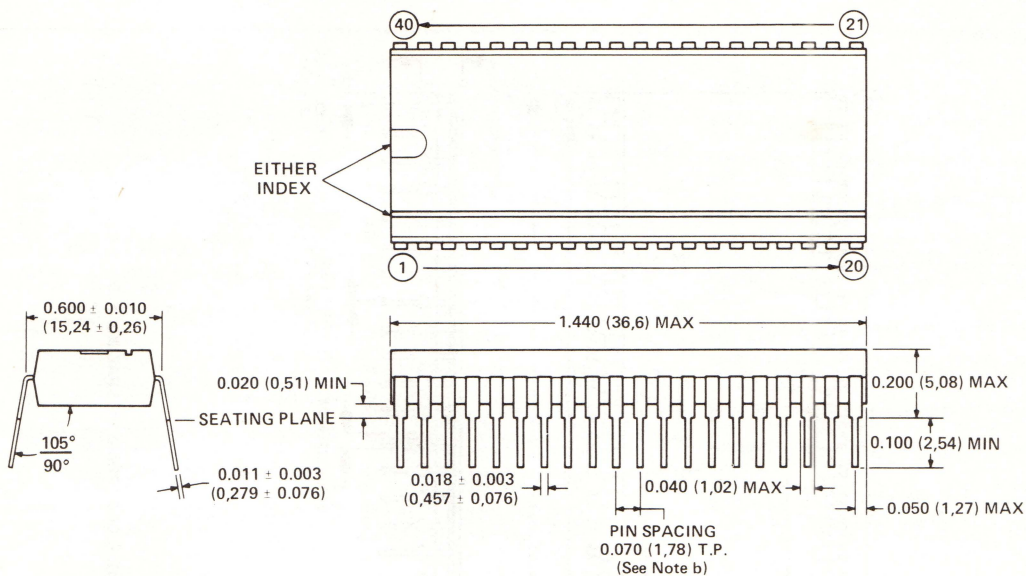
NOTES: a. All linear dimensions are in inches and parenthetically in millimeters. Inch dimensions govern.
b. Each pin centerline is located within 0.010 (0,26) of its true longitudinal position.

FIGURE 51 – 28-PIN NF PLASTIC PACKAGE, 0.070" PIN CENTER SPACING, 0.400" PIN ROW SPACING



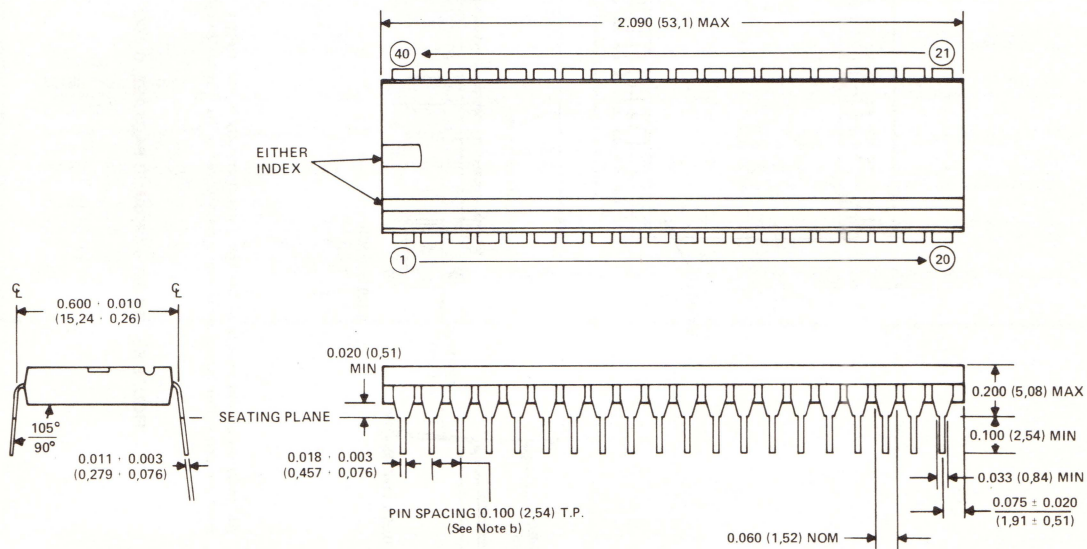
NOTES: a. All linear dimensions are in inches and parenthetically in millimeters. Inch dimensions govern.
b. Each pin centerline is located within 0.010 (0,26) of its true longitudinal position.

FIGURE 52 – 28-PIN N PLASTIC PACKAGE 0.100" PIN CENTER SPACING, 0.600" PIN ROW SPACING



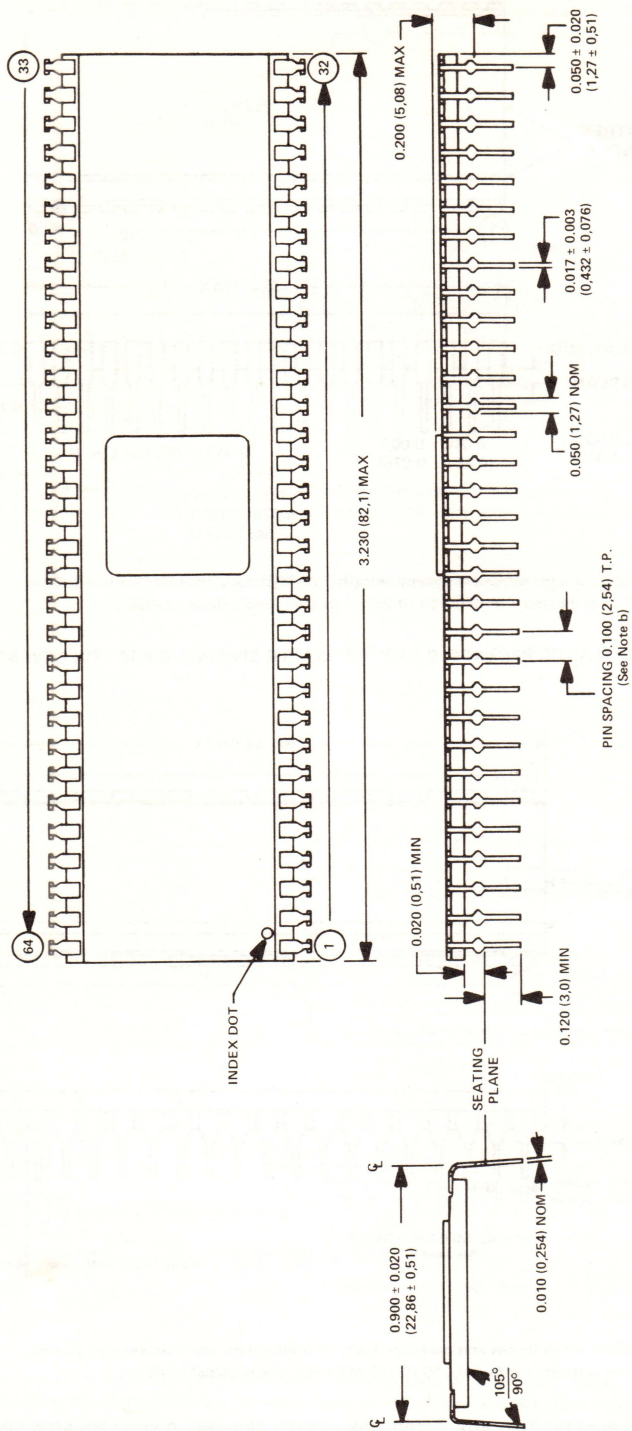
NOTES: a. All linear dimensions are in inches and parenthetically in millimeters. Inch dimensions govern.
b. Each pin centerline is located within 0.010 (0.26) of its true longitudinal position.

FIGURE 53—40-PIN NF PLASTIC PACKAGE, 0.070" PIN CENTER SPACING, 0.600" PIN ROW SPACING



NOTES: a. All linear dimensions are in inches and parenthetically in millimeters. Inch dimensions govern.
b. Each pin centerline is located within 0.010 (0.26) of its true longitudinal position.

FIGURE 54—40-PIN N PLASTIC PACKAGE, 0.100" PIN CENTER SPACING, 0.600" PIN ROW SPACING



NOTES: a. All linear dimensions are in inches and parenthetically in millimeters. Inch dimensions govern.
b. Each pin centerline is located within 0.010 (0.26) of its true longitudinal position.

FIGURE 55 - 64-PIN J CERAMIC PACKAGE, 0.100" PIN CENTER SPACING, 0.900" PIN ROW SPACING

TI Worldwide Sales Offices

ALABAMA: Huntsville, 500 Wynn Drive, Suite 514, Huntsville, AL 35805, (205) 837-7530.

ARIZONA: Phoenix, P.O. Box 35160, 8102 N. 23rd Ave., Suite A, Phoenix, AZ 85069, (602) 995-1007.

CALIFORNIA: El Segundo, 831 S. Douglas St., El Segundo, CA 90245, (213) 973-2571; Irvine, 17620 Fitch, Irvine, CA 92714, (714) 545-5210; Sacramento, 1900 Point West Way, Suite 171, Sacramento, CA 95815, (916) 929-1521; San Diego, 4333 View Ridge Ave., Suite B, San Diego, CA 92123, (714) 278-9600; Santa Clara, 5353 Betsy Ross Dr., Santa Clara, CA 95051, (408) 748-2300; Woodland Hills, 21220 Erwin St., Woodland Hills, CA 91367, (213) 704-7759.

COLORADO: Denver, 9725 E. Hampden St., Suite 301, Denver, CO 80231, (303) 695-2800.

CONNECTICUT: Wallingford, 9 Barnes Industrial Park Rd., Barnes Industrial Park, Wallingford, CT 06492, (203) 269-0074.

FLORIDA: Clearwater, 2280 U.S. Hwy. 19 N., Suite 232, Clearwater, FL 33515, (813) 796-1926; Ft. Lauderdale, 2765 N.W. 62nd St., Ft. Lauderdale, FL 33309, (305) 973-8502; Maitland, 2601 Maitland Center Parkway, Maitland, FL 32751, (305) 646-9600.

GEORGIA: Atlanta, 3300 Northeast Expy., Building 9, Atlanta, GA 30341, (404) 452-4600.

ILLINOIS: Arlington Heights, 515 W. Algonquin, Arlington Heights, IL 60005, (312) 640-2934.

INDIANA: Ft. Wayne, 2020 Inwood Dr., Ft. Wayne, IN 46805, (219) 424-5174; Indianapolis, 2346 S. Lynhurst, Suite J-400, Indianapolis, IN 46241, (317) 248-8555.

ARGENTINA: Texas Instruments Argentina S.A.I.C.F. Km. 25, 5 Ruta Panamericana Don Torcuato, C.C. 2296, 1000-Correo Central, Buenos Aires, Argentina, 748-1141.

AUSTRALIA: Texas Instruments Australia Ltd. Unit 1A, 9 Byfield St., P.O. Box 106, North Ryde, N.S.W. 2113, Sydney, Australia, 02-867-1122, 5th floor, 418 St. Kilda Road, Melbourne, 3004, Victoria, Australia, 03-267-4677.

AUSTRIA: Texas Instruments Ges. m.b.H. Rennweg 17, 1030 Vienna, Austria, 0222-724186.

BELGIUM: Texas Instruments S/A: Mercure Centre, Raketstraat, Rue De La Fusee 100, 1130 Brussels, Belgium, 02-7208000.

BRAZIL: Texas Instruments Electronicos do Brasil Ltda: Rua Padre Pereira De Andrade, 591 Cep-05469 Sao Paulo, Brazil, 011-260-6347.

DENMARK: Texas Instruments A/D: Marielundvej 46E, 2730 Herlev, Denmark, 02-917400.

FINLAND: Texas Instruments Finland OY: Fressenkatu 6, P.L. 917, 00101 Helsinki 10, Finland, 80-408300.

FRANCE: Texas Instruments France: La Boursidiere, Bat. A, R.N. 186, 92350 Le Plessis Robinson, France, 01-6302343; 31 Quai Rambaud, 69002 Lyon, France, 078-373585; 1, Av. de la Chartreuse, 38240 Meylan, France, 078-904574; 9, Place de Bretagne, 35000 Rennes, France, 099-795461; 100-102 Alle de Barcelone, Residence L'Autay, 31000 Toulouse, France, 061-213032.

IOWA: Cedar Rapids, 373 Collins Rd. NE, Suite 200, Cedar Rapids, IA 52402, (319) 395-9550.

MARYLAND: Baltimore, 1 Rutherford Pl., 7133 Rutherford Rd., Baltimore, MD 21207, (301) 944-8600.

MASSACHUSETTS: Waltham, 504 Totten Pond Rd., Waltham, MA 02154, (617) 890-7400.

MICHIGAN: Farmington Hills, 33737 W. 12 Mile Rd., Farmington Hills, MI 48018, (313) 553-1500.

MINNESOTA: Edina, 7625 Parklawn, Edina, MN 55435, (612) 830-1600.

MISSOURI: Kansas City, 8080 Ward Pkwy., Kansas City, MO 64114, (816) 523-2500; St. Louis, 11861 Westline Industrial Drive, St. Louis, MO 63141, (314) 569-7600.

NEW JERSEY: Clark, 292 Terminal Ave. West, Clark, NJ 07066, (201) 574-9800.

NEW MEXICO: Albuquerque, 5907 Alice NSE, Suite E, Albuquerque, NM 87110, (505) 265-8491.

NEW YORK: East Syracuse, 6700 Old Collamer Rd., East Syracuse, NY 13057, (315) 463-9291; Endicott, 112 Nanticoke Ave., P.O. Box 618, Endicott, NY 13760, (607) 754-3900; Melville, 1 Huntington Quadrangle, Suite 3C10, P.O. Box 2936, Melville, NY 11747, (516) 454-6600; Poughkeepsie, 201 South Ave., Poughkeepsie, NY 12601, (914) 473-2900; Rochester, 1210 Jefferson Rd., Rochester, NY 14623, (716) 424-5400.

NORTH CAROLINA: Charlotte, 8 Woodlawn Green, Woodlawn Rd., Charlotte, NC 28210, (704) 527-0930.

OHIO: Beachwood, 23408 Commerce Park Rd., Beachwood, OH 44122, (216) 464-6100; Dayton, Kingsley Bldg., 4124 Linden Ave., Dayton, OH 45432, (513) 258-3877.

OKLAHOMA: Tulsa, 3105 E. Skelly Dr., Suite 110, Tulsa, OK 74105, (918) 749-9547.

OREGON: Beaverton, 6700 SW 105th St., Suite 110, Beaverton, OR 97005, (503) 643-6758.

PENNSYLVANIA: Ft. Washington, 575 Virginia Dr., Ft. Washington, PA 19034, (215) 643-6450.

TENNESSEE: Johnson City, P.O. Drawer 1255, Erwin Hwy., Johnson City, TN 37601, (615) 461-2191.

TEXAS: Austin, 12501 Research Blvd., P.O. Box 2909, Austin, TX 78723, (512) 250-7655; Dallas, P.O. Box 225012, Dallas, TX 75265, (214) 995-6531; Houston, 9100 Southwest Frwy., Suite 237, Houston, TX 77036, (713) 778-6592; San Antonio, 1000 Central Park South, San Antonio, TX 78217, (512) 496-1779.

UTAH: Salt Lake City, 3672 West 2100 South, Salt Lake City UT 84120, (801) 973-6310.

VIRGINIA: Fairfax, 3001 Prosperity, Fairfax, VA 22031, (703) 849-1400; Midlothian, 13711 Sutter's Mill Circle, Midlothian, VA 23113, (804) 744-1007.

WISCONSIN: Brookfield, 205 Bishops Way, Suite 214, Brookfield, WI 53005, (414) 784-3040.

WASHINGTON: Redmond, 2723 152nd Ave., N.E. Bldg 6, Redmond, WA 98052, (206) 881-3080.

CANADA: Ottawa, 436 McClaren St., Ottawa, Canada, K2P0M6, (613) 233-1177; Richmond Hill, 280 Centre St. E., Richmond Hill L4C1B1, Ontario, Canada, (416) 884-9181; St. Laurent, Ville St. Laurent Quebec, 9460 Trans Canada Hwy., St. Laurent, Quebec, Canada H4S1R7, (514) 334-3635.

GERMANY: Texas Instruments Deutschland GmbH: Kurfuerstendamm 146, 1000 Berlin 31, Germany, 030-8927013; Ill Hagen 43, Frankfurter Allee 6-8, 6236 Eschborn, Germany, 06196-43074; 4300 Essen, Germany, 0201-233551; Winterthurer Weg 8, 2000 Hamburg 76, Germany, 040-2201154; Haggertystrasse 1, 8050 Freising, Germany, 08161-801; Riethorst 4, 3000 Hannover 51, Germany, 0511-648021; Arabellastrasse 13-15, 8000 Munich 81, Germany, 089-92341; Marienrothgraben 3-5, 8500 Nuernberg, Germany, 0911-22877; Krefelderstrasse 11-15, 7000 Stuttgart 50, Germany, 0711-547001.

HONG KONG: Texas Instruments Asia Ltd: 902, Asian House, 1, Hennessy Rd., Hong Kong, 05-279041.

ITALY: Texas Instruments Italia Spa: Via Europa 38/44, Cologno Monzese, Milan, Italy, 02-253-2451; Via Salaria 1319, 00138 Rome, Italy, 06-6917127; Via Montebello 27, 10124 Turin, Italy, 011-832276.

JAPAN: Texas Instruments Asia Ltd: Aoyama Fuji Bldg., 4F, 3-6-12, Kita-Aoyama, Minato-ku, Tokyo, Japan 107, (03) 498-2111.

KOREA: Texas Instruments Supply Company: Room 301, Kwang Poong Bldg., 24-1 Hwangyang Dong, Sungdong-Ku, Seoul, Korea, 447-6274.

MEXICO: Texas Instruments de Mexico S.A.: Poniente 116 #489, Col. Industrial Vallejo, Mexico City 02300, D.F., Mexico, 905-567-9200.

NETHERLANDS: Texas Instruments Holland BV: Laan Van de Helende Meesters 421 A, P.O. Box 283, 1180 AG Amstelveen, Holland, 020-473391.

NORWAY: Texas Instruments A/S: Ryensvingen 15, Oslo 6, Norway, 02-689487.

PHILIPPINES: Texas Instruments Asia Ltd: 14th Floor, BA-Lepanto Building, Paseo De Roxas, Makati, Metro Manila, 818-89-87.

PORTUGAL: Texas Instruments Equipamento Electronico LDA: Rua Eng. Frederico Ulrich, 2650 Moreira Da Maia, Douro, Portugal, 948-1003.

SINGAPORE: Texas Instruments Asia Ltd: P.O. Box 2093, 990 Bendemeer Rd., Singapore 1233, Republic of Singapore, 65-2581122.

SPAIN: Texas Instruments Espana S.A.: Balmes 89, 12 Barcelona 12, Spain.

SWEDEN: Texas Instruments International Trade Corporation (Sverigefilialen): Norra Hannvagen 3, Fack S-100 54 Stockholm 39, Sweden, 08-235480.

TAIWAN: Texas Instruments Taiwan Ltd: 10th floor, Fu Shing Bldg., 71 Sung-Kiang Rd., Taipei, Taiwan, Republic of China, 05-5219321.

UNITED KINGDOM: Texas Instruments Ltd: Manton Lane, Bedford, England MK417PU, 0234-67466.

TEXAS INSTRUMENTS
INCORPORATED

TI Sales Offices

ALABAMA: Huntsville, 500 Wynn Drive, Suite 514, Huntsville, AL 35805, (205) 837-7530.

ARIZONA: Phoenix, P.O. Box 35160, 8102 N. 23rd Ave., Suite A, Phoenix, AZ 85069, (602) 995-1007.

CALIFORNIA: El Segundo, 831 S. Douglas St., El Segundo, CA 90245, (213) 973-2571; Irvine, 17820 Fitch, Irvine, CA 92714, (714) 545-5210; Sacramento, 1900 Point West Way, Suite 171, Sacramento, CA 95815, (916) 929-1521; San Diego, 4333 View Ridge Ave., Suite B, San Diego, CA 92123, (714) 278-9600; Santa Clara, 5353 Betsy Ross Dr., Santa Clara, CA 95051, (408) 748-2300; Woodland Hills, 21220 Erwin St., Woodland Hills, CA 91367, (213) 704-7759.

COLORADO: Denver, 9725 E. Hampden St., Suite 301, Denver, CO 80231, (303) 695-2800.

CONNECTICUT: Wallingford, 9 Barnes Industrial Park Rd., Barnes Industrial Park, Wallingford, CT 06492, (203) 269-0074.

FLORIDA: Clearwater, 2280 U.S. Hwy. 19 N., Suite 232, Clearwater, FL 33515, (813) 796-1926; Ft. Lauderdale, 2765 N.W. 62nd St., Ft. Lauderdale, FL 33309, (305) 973-8502; Maitland, 2601 Maitland Center Parkway, Maitland, FL 32751, (305) 646-9600.

GEORGIA: Atlanta, 3300 Northeast Expy., Building 9, Atlanta, GA 30341, (404) 425-4600.

ILLINOIS: Arlington Heights, 515 W. Algonquin, Arlington Heights, IL 60005, (312) 640-2934.

INDIANA: Ft. Wayne, 2020 Inwood Dr., Ft. Wayne, IN 46805, (219) 424-5174; Indianapolis, 2346 S. Lynhurst, Suite J-400, Indianapolis, IN 46241, (317) 248-8555.

IOWA: Cedar Rapids, 373 Collins Rd. NE, Suite 200, Cedar Rapids, IA 52402, (319) 395-9550.

MARYLAND: Baltimore, 1 Rutherford Pl., 7133 Rutherford Rd., Baltimore, MD 21207, (301) 944-8600.

MASSACHUSETTS: Waltham, 504 Totten Pond Rd., Waltham, MA 02154, (617) 890-7400.

MICHIGAN: Farmington Hills, 33737 W. 12 Mile Rd., Farmington Hills, MI 48018, (313) 553-1500.

MINNESOTA: Edina, 7625 Parklawn, Edina, MN 55435, (612) 830-1600.

MISSOURI: Kansas City, 8080 Ward Pkwy., Kansas City, MO 64114, (816) 523-2500; St. Louis, 11861 Westline Industrial Drive, St. Louis, MO 63141, (314) 569-7600.

NEW JERSEY: Clark, 292 Terminal Ave. West, Clark, NJ 07066, (201) 574-9800.

NEW MEXICO: Albuquerque, 5907 Alice NSE, Suite E, Albuquerque, NM 87110, (505) 265-8491.

NEW YORK: East Syracuse, 6700 Old Collamer Rd., East Syracuse, NY 13057, (315) 463-9291; Endicott, 112 Nanticoke Ave., P.O. Box 618, Endicott, NY 13760, (607) 754-3900; Melville, 1 Huntington Quadrangle, Suite 3C10, P.O. Box 2936, Melville, NY 11747, (516) 454-6600; Poughkeepsie, 201 South Ave., Poughkeepsie, NY 12601, (914) 473-2900; Rochester, 1210 Jefferson Rd., Rochester, NY 14623, (716) 424-5400.

NORTH CAROLINA: Charlotte, 8 Woodlawn Green, Woodlawn Rd., Charlotte, NC 28210, (704) 527-0930.

OHIO: Beachwood, 23408 Commerce Park Rd., Beachwood, OH 44122, (216) 454-6100; Dayton, Kingsley Bldg., 4124 Linden Ave., Dayton, OH 45432, (513) 258-3877.

OKLAHOMA: Tulsa, 3105 E. Skelly Dr., Suite 110, Tulsa, OK 74105, (918) 749-9547.

OREGON: Beaverton, 6700 SW 105th St., Suite 110, Beaverton, OR 97005, (503) 643-6758.

PENNSYLVANIA: Ft. Washington, 575 Virginia Dr., Ft. Washington, PA 19034, (215) 643-6450.

TENNESSEE: Johnson City, P.O. Drawer 1255, Erwin Hwy., Johnson City, TN 37601, (615) 461-2191.

TEXAS: Austin, 12501 Research Blvd., P.O. Box 2909, Austin, TX 78723, (512) 250-7555; Dallas, P.O. Box 225012, Dallas, TX 75285, (214) 995-6531; Houston, 9100 Southwest Freeway, Suite 237, Houston, TX 77036, (713) 778-6592; San Antonio, 1000 Central Park South, San Antonio, TX 78217, (512) 496-1779.

UTAH: Salt Lake City, 3672 West 2100 South, Salt Lake City UT 84120, (801) 973-6310.

VIRGINIA: Fairfax, 3001 Prosperity, Fairfax, VA 22031, (703) 849-1400; Midlothian, 1371 Sutter's Mill Circle, Midlothian, VA 23113, (804) 744-1007.

WISCONSIN: Brookfield, 205 Bishops Way, Suite 214, Brookfield, WI 53005, (414) 784-3040.

WASHINGTON: Redmond, 2723 152nd Ave., N.E. Bldg 6, Redmond, WA 98052, (206) 881-3080.

CANADA: Ottawa, 436 McClaren St., Ottawa, Canada, K2P0M8, (613) 233-1177; Richmond Hill, 280 Centre St. E., Richmond Hill L4C1B1, Ontario, Canada, (416) 884-9181; St. Laurent, Ville St. Laurent Quebec, 9460 Trans Canada Hwy., St. Laurent, Quebec, Canada H4S1R7, (514) 334-3635. P

TI Distributors

ALABAMA: Hall-Mark (205) 837-8700.

ARIZONA: Phoenix, Kierulff (602) 243-4101; Marshall (602) 968-6181; R.V. Weatherford (602) 272-7144; Wyle (602) 249-2232; Tucson, Kierulff (602) 624-9986.

CALIFORNIA: Los Angeles/Orange County, Arrow (213) 701-7500, (714) 851-8961; JACO (714) 540-5600, (213) 998-2200; Kierulff (213) 725-0325, (714) 731-5711; Marshall (213) 999-5001, (213) 686-0141, (714) 556-6400; RPS (213) 744-0355, (714) 521-5230; R.V. Weatherford (714) 634-9600, (213) 849-3451, (714) 623-1261; Time (213) 320-0880; Wyle (213) 322-8100, (714) 641-1611; San Diego, Arrow (714) 565-4800; Kierulff (714) 278-2112; Marshall (714) 578-9600; R.V. Weatherford (714) 695-1700; Wyle (714) 565-9171; San Francisco Bay Area, Arrow (408) 745-6600; Kierulff (415) 958-6292; Marshall (408) 732-1100; Time (408) 734-9688; United Components (408) 496-6900; Wyle (408) 727-2500; Santa Barbara, RPS (805) 964-6823; R.V. Weatherford (805) 465-8551.

COLORADO: Arrow (303) 758-2100; Diplomat (303) 740-8300; Kierulff (303) 371-6500; R.V. Weatherford (303) 428-6900; Wyle (303) 457-9953.

CONNECTICUT: Arrow (203) 265-7741; Kierulff (203) 265-1115; Marshall (203) 265-3822; Milgray (203) 795-0714.

FLORIDA: Ft. Lauderdale, Arrow (305) 973-8502; Diplomat (305) 971-7160; Hall-Mark (305) 971-9280; Kierulff (305) 652-6950; Orlando, Arrow (305) 725-1480; Diplomat (305) 725-4520; Hall-Mark (305) 855-4020; Milgray (305) 647-5747; Tampa, Diplomat (813) 443-4514; Kierulff (813) 576-1966.

GEORGIA: Arrow (404) 449-8252; Hall-Mark (404) 447-8000; Marshall (404) 923-5750.

ILLINOIS: Arrow (312) 893-9420; Diplomat (312) 595-1000; Hall-Mark (312) 860-3800; Kierulff (312) 640-0200; Newark (312) 638-4411.

INDIANA: Indianapolis, Arrow (317) 243-9353; Graham (317) 634-8202; Ft. Wayne, Graham (219) 423-3422.

IOWA: Arrow (319) 395-7230; Deeco (319) 365-7551.

KANSAS: Kansas City, Component Specialties (913) 492-3555; Hall-Mark (913) 888-4747; Wichita, LCOMP (316) 265-9507.

MARYLAND: Arrow (301) 247-5200; Diplomat (301) 995-1226; Hall-Mark (301) 796-9300; Milgray (301) 468-6400.

MASSACHUSETTS: Arrow (617) 933-8130; Diplomat (617) 429-4120; Kierulff (617) 667-8331; Marshall (617) 272-8200; Time (617) 935-8080.

MICHIGAN: Detroit, Arrow (313) 971-8200; Diplomat (313) 477-3200; Newark (313) 967-0600; Grand Rapids, Newark (616) 241-6681.

MINNESOTA: Arrow (612) 830-1800; Diplomat (612) 788-8601; Hall-Mark (612) 854-3223; Kierulff (612) 941-7500.

MISSOURI: Kansas City, LCOMP (816) 221-2400; St. Louis, Arrow (314) 567-6888; Hall-Mark (314) 291-5350; Kierulff (314) 739-0855.

NEW HAMPSHIRE: Arrow (603) 668-6968.

NEW JERSEY: North, Arrow (201) 797-5800; Diplomat (201) 785-1830; JACO (201) 778-4722; Kierulff (201) 575-6750; Marshall (201) 340-1900; South, Arrow (609) 235-1900; General Radio (609) 964-8560; Hall-Mark (609) 424-0880; Milgray (609) 424-1300.

NEW MEXICO: Arrow (505) 243-4566; International Electronics (505) 343-8127.

NEW YORK: Long Island, Arrow (516) 231-1000; Diplomat (516) 454-6400; JACO (516) 273-5500; Milgray (516) 546-5600; (800) 645-3986; OPL (516) 467-1200; Rochester, Arrow (716) 275-0300; Marshall (716) 235-7620; Rochester Radio Supply (716) 454-7800; Syracuse, Arrow (315) 652-1000; Diplomat (315) 652-5000; Marshall (607) 754-1570.

NORTH CAROLINA: Arrow (919) 876-3132, (919) 725-8711; Hall-Mark (919) 872-0712; Kierulff (919) 852-6261.

OHIO: Cincinnati, Graham (513) 772-1661; Cleveland, Arrow (216) 248-3990; Hall-Mark (216) 473-2907; Kierulff (216) 587-6558; Columbus, Hall-Mark (614) 846-1892; Dayton, Arrow (513) 435-5563; ESCO (513) 226-1133; Marshall (513) 236-8088.

OKLAHOMA: Component Specialties (918) 664-2820; Hall-Mark (918) 665-3200; Kierulff (918) 252-7537.

OREGON: Almac/Stroum (503) 641-9070; Kierulff (503) 641-9150; Wyle (503) 640-6000.

PENNSYLVANIA: Arrow (412) 856-7000.

TEXAS: Austin, Arrow (512) 835-4180; Component Specialties (512) 837-8922; Hall-Mark (512) 258-8848; Kierulff (512) 835-2090; Dallas, Arrow (214) 386-7500; Component Specialties (214) 357-6511; Hall-Mark (214) 341-1147; International Electronics (915) 778-9761; Houston, Arrow (713) 491-4100; Component Specialties (713) 771-7237; Hall-Mark (713) 761-6100; Harrison Equipment (713) 879-2600; Kierulff (713) 530-7030.

UTAH: Diplomat (801) 486-4134; Kierulff (801) 973-6913; Wyle (801) 974-9953.

WASHINGTON: Almac/Stroum (206) 643-9992; Arrow (206) 575-0907; Kierulff (206) 575-4240; United Components (206) 643-7444; Wyle (206) 453-8300.

WISCONSIN: Arrow (414) 764-6600; Hall-Mark (414) 761-3000; Kierulff (414) 784-8160.

CANADA: Calgary, Future (403) 259-6408; Varah (403) 230-1235; Downsview, CESCO (416) 661-0220; Hamilton, Varah (416) 561-9311; Montreal, CESCO (514) 735-5511; Future (514) 694-7710; Ottawa, CESCO (613) 226-6905; Future (613) 820-8313; Quebec City, CESCO (418) 867-4231; Toronto, Future (416) 663-5563; Vancouver, Future (604) 438-5545; Varah (604) 873-3211; Winnipeg, Varah (204) 633-6190. Al

TEXAS INSTRUMENTS INCORPORATED



TEXAS INSTRUMENTS
INCORPORATED

JUNE 1982

MP056

Post Office Box 1443 / Houston, Texas 77001
Semiconductor Group

Printed in U.S.A.